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Special Issue on Biorefineries: Prospects, Problems and Perspective for Developing Countries

Guest Editor: Edgar J. DaSilva

- Mining of Biowealth through Use of Clean and Green Technologies
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- A Model for Zero Emission Biotechnology in Asian Countries
  Hitomi Ohara
- Biorefineries: A Contribution to the Human Face of Biotechnology
  Horst W. Doelle and Edgar J. DaSilva
- From Petro to Agro: Seeds of a New Economy
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- Bioconversion Energy Technologies: Catalysts for Bioeconomical Development in the ASEAN Region
  Kamaruddin Abdullah
- Marine Biotechnology: A Natural Biorefinery Source of Marine Products and By-products for Human Welfare
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- Renewable Energies for North and Central Asian Countries: Bioeconomics, Environment and Social Impact
  Aldo Iacomelli
- In Memory of Dr Edgar DaSilva
  Lucy Hoareau

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Dr. Edgar J. DaSilva

(1941-2007)

Dr. Edgar J. DaSilva passed away on 28 October 2007 in Mumbai, India. Dr. DaSilva was closely associated with RIS' work programme for a long time and was as an Adjunct Senior Fellow. He had been a keen supporter and contributor to RIS work programme on Biotechnology and Development ever since it was launched in 1987. He served on the Editorial Board of the Review right from its inception. Dr. DaSilva had agreed to serve as the Guest Editor for this special issue of the ABDR on biorefineries. He also contributed a joint article with Dr. Horst W. Doelle this issue.

The members of ABDR Editorial Board and members of RIS faculty express their heartfelt condolence to the bereaved family. The issue also carries a special tribute to Dr. DaSilva by Ms. Lucy Hoareau of UNESCO.

This issue of ABDR is dedicated to his memory.

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Mining of Biowealth through Use of Clean and Green Technologies

Introduction

Edgar J. DaSilva

Humankind is dependent upon energy resources that fuel its cultural, socio-economic and technological advancement through decade after decade. The last century was exemplified as the era of *black* gold. In its first decade this century has witnessed efforts to tap the benefits of investing in *green* gold; economic misgivings and ethical skepticisms concerning policies focusing on food versus energy production. Using the toolbox colours of Mother Nature, black gold is today often recognized as a *grey* technology[1] that has left in its wake a virtually uncontrollable and undoable fall out as was evident in the neglect of surveillance signs and symptoms in the last quarter of the twentieth century. These are climate change; global warming, emergence of new diseases, and socio-cultural afflictions of non-microbial origin. Black gold and its newly-discovered natural occurrence worldwide whilst fuelling the dreams and hopes of a continent[2] long forgotten is forging new political inter-relationships[3] with Asia and the Far East, while in the Middle East and South America[4], it is redefining the geopolitics of oil and foreign policy orientation especially in the northern hemisphere. The political *puissance du robinet* that distributes oil and other fossil-fuel derivatives determines the degrees of comfort and discomfort of offices and homes in wealthy cities and towns lacking dependent supplies of oil and natural gas[5] in harsh winters. As a consequence new regional security alliances such as the Shanghai Cooperation Organisation (SCO) [6] are emerging that are likely to force a review of international financial governance and institutions such as the International Monetary Fund (IMF) and the World Bank (WB). Notwithstanding the occurrence and use of oil in ancient times[7] the era of easy and inexpensive oil is over.[8]

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* Former Director, Division of Life Sciences, UNESCO, Paris & Co-Editor UNESCO-EOLSS Biotechnology Theme and Adjunct Senior Fellow, RIS.

It's incredible, isn't it, when you stop to consider the scale of the society we have created, and to also ponder how things could have been if we had taken an alternate path - if we had recognized that there is no such thing as oil 'production', as we continually refer to it (in the sense that we cannot create oil any more than we can create gold), but only oil extraction. We do not manufacture oil, we mine it.[9]

On the other hand, the benefits of green gold are evident. Petrorefineries are giving way to biorefineries. R&D is *a la mode* in these contemporary times. Biofuels are redrawing the map of world agriculture.[10] A strategy built around first- and second-generation biofuels aims to reduce the overdependency of the European Union and developing countries fossil-fuel use especially in the transport sector.[11] In the Pacific islands of Fiji, New Caledonia, Papua New Guinea, Vanuatu, and the island of Savai'l in Western Samoa research and feasibility studies are underway to tap coconut oil as a biofuel for electricity generation and as biodiesel in the transport sector.[12]

In Asia the emerging two powerhouses of green biotechnology, namely China and India are putting their stamp on the world's bioeconomy-based markets that influence global agricultural and biofuels trade. The Asian Development Bank (ADB) is apparently investing US$ 900 million into "clean energy development projects in 2007, with priority given to China, India, Indonesia, Pakistan, the Philippines and Vietnam".[13] The issues of eradication of poverty and gender equality have not been glossed over as is evident from the 'Pro-Poor Biofuels Initiative' of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)[14] in India. Targeted areas of the initiative are: food security, energy and provision of opportunities for small and marginal farmers in the drylands and for their participation in the "global biofuels revolution".[15]

However, though the clean and green biorefineries that range in scale from the rural to the bioindustrial sector have been widely promoted and accepted there are still concerns and negative impacts that have been voiced in various fora. Ethical issues are reminiscent of the concerns and debates expressed some three decades ago when Gasohol was first proposed as a transport fuel. At that time the emphasis was on loss of land and thus food production and fuel production as ethanol for the transportation sector. In current times the issues are many. These include for example ensuring energy security through provision of uninterrupted supplies; reducing greenhouse gas emissions; reclamation and protection of soil use of residual cakes of inedible oil plants; enhancing rural economies; providing opportunities for development of new rural markets; and redressing gender inequality in rural and urban employment markets. A recent UN report[16] draws attention to several potential and probable negative aspects of biofuels production and use. These *en bref* are:

- use of arable land for development of bioenergy plantations instead of use for food production;
- replacement of tropical rain forestation with that of biofuel plantations;
- large-scale biofuel monocropping that contributes to soil erosion and nutrient leaching and above all loss of biodiversity; and endangering the livelihoods of small-scale rural and village farmers who are constantly being confronted with mechanized large-scale biofuel plantations and refineries.

Through promotion of a worldwide dialogue between businesses and consumers in the context of the *Business of Green*[17] attention is now being focused on issues such as 'Crops for biofuels vs. food supplies'. This not only informs the public and private sectors but also helps to educate decision- and policy-makers in sustainable development of the possible use of biotech solutions to secure an aesthetic and clean environment. This is apparent in the combination in the use of renewable energy with that of urban design based upon the principle of zero carbon, zero waste cities and villages that is the building of cities and villages in consonance with nature. Examples of ecocities and ecovillages or *green* cities and villages are: Bedzed, London, U.K. (ecovillage); Dongtan, near Shanghai, China; and the Masdar initiative in Abu Dhabi.

The contributors to this special volume have addressed many of the above issues that are of significance to using biorefineries in clean, green and environmentally technologies.

Professor Ohara (Japan) describes a model for zero emission biotechnology in Asian countries. The ultimate goal is the construction of biorefineries that are fully integrated with nature in contributing to the sustenance of economic development and a safe and unpolluted environment. This in essence is another expression of the 'zero carbon, zero waste' concept of development linked to ecovillages and ecocities.

Dr. Robert Armstrong (USA) in a visionary contribution indicates with conviction that the world's economic foundation is already shifting out of necessity from a system based on petroleum to another based on biologically derived raw materials. The basic unit of commerce is changing from the hydrocarbon molecule to the gene. This shift enhances the profile of agriculture as the source of not only food, feed and fibre, but also of energy, materials and chemicals.

Professor Kamaruddin Abdullah (Indonesia) emphasises that despite the multiple benefits offered by bioconversion technology there are still obstacles that have to be overcome in several ASEAN countries in deploying biomass as a valuable bioresource in bioeconomical development.

Professors Indrani Karunasagar and Iddya Karunasagar draw attention to the bioresources of the deep ocean once considered to be a 'biological desert'. Given that four-fifth's of all life forms inhabit this ecological niche, the importance of marine organisms as a biorefinery technology resource is overwhelming.

Professor Aldo Iacomelli (Italy) focuses on decentralised cooperation in the implementation of programmes and their real (positive or negative) impact on local communities, which is inclusive of adaptation and the mitigation of global warming and climate change due to Greenhouse Gas (GHG) emissions. This strict connection with local investors also suggests different financial instruments that can define and record the evidence and relevance of environmental and social implication rather than financial results. The enunciation of the Kyoto Bond shows the interaction between non financial performance and market performance.

Finally, Professors Horst Doelle (Australia) and Edgar DaSilva (France) in an overview address several important issues that indicate that the challenges for the future are to be found in a combination of the biological, physical and chemical sciences in replicating an 'oil refinery' with a 'bio-refinery' thus replacing finite non-renewable fossil resources with biorenewable biomass resources for the production of food, feed, fertiliser, fuel, energy, industrial chemicals and related consumer products. The use of clean and green bioprocess technologies is indisputable.

Endnotes

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[3] Pan (2007).

[4] Bartley and O'Briain (2003). See also the 'Politics of Oil in Digital History' (http://www.digitalhistory.uh.edu/historyonline/oil.cfm) in site update: June 10, 2007.

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A Model for Zero Emission Biotechnology in Asian Countries

Hitomi Ohara*

Abstract: Our civilization which began to depend on oil in the twentieth century is now entirely dependent on it. For example, the gasoline used to fuel automobiles is a mixture of hydrocarbons from C_6H_{14} to $C_{12}H_{26}$ that are refined from crude oil. Kerosene is made from C10–C15 hydrocarbons and is used as a jet fuel. Diesel fuel (light oil) is made from C10–C20 hydrocarbons, and the heavy oils used to fuel ships are made from longer-chain hydrocarbons. The residue from refined fuels is called coal tar and is used for making roads. Electricity is generated using heat produced by burning coal, oil, and, recently, liquefied natural gas. Crude oil is also used in the manufacture of light and non-biodegradable plastics and its extensive use during the twentieth century has contributed to global warming and the ongoing climate crisis. The oil from which petroleum is produced is a fossil resource and its global production and availability is expected to peak in the coming decades. Several options for switching over to alternative energy sources such as zero-emission biotechnology and biorefineries are being explored to ensure the security of energy supplies but also for military security. However, the ultimate goal is the construction of biorefineries that are fully integrated with nature in contributing to the sustenance of economic development and a safe and unpolluted environment.

Keywords: Biorefineries, Climate crisis, Green chemistry, Sustainable chemistry, White biotechnology

Climate Crisis and Global Warming

The problems of the climate crisis and of global warming are increasingly pressing. The fourth assessment report of the Intergovernmental Panel on Climate Change[1] said that the average temperature at the end of the twenty first century will be about 1.8°C (1.1–2.9°C) higher than that in 1980–99 if we achieve the recycling society—a society that sustains the environment by saving resources— whereas it will increase by about

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4.0°C (2.4–6.4°C) if high economic growth is maintained. Sea level will rise by about 18–38 and 26–59 cm in these two scenarios, respectively causing, of course, extensive damage.[2] Islands such as Tuvalu, Fiji, the Marshall Islands, and the Maldives Islands which have already been exposed to the crisis of submergence will vanish if such predictions are fulfilled. Moreover, coastal areas, especially the heavily populated mega-delta regions in South, East, and Southeast Asia, will be at great risk because of increased flooding from the sea and, in the case of some mega deltas flooding from rivers.[3] The lives of 228,000 people have been devastated by flood damage in Asia between 1987 and 1997. In Japan, an area of about 861 km² is below the water level of the flood tide, i.e., the area is below sea level; and, has a population of 2 million people and property worth 54 trillion yen.[4] A large number of homeless people might have become environmental refugees. The effect of global warming is not limited to a rise in sea level. It is thought that global warming caused by greenhouse gases resulted in the deaths of about 35,000 people during the heat wave that hit Europe in 2003.[5] Global warming also has a serious effect on the ecosystem. For instance, it is not possible for plants and grass to survive because the trees can grow, on average, only at 40 m/year. The climate belt to which Japan belongs, is moving northwards at 6 km/y as a result of global warming. Many scientists have suggested that global warming contributed to Hurricane Katrina, which hit the USA in August, 2005.[6] Katrina caused extensive damage to oil refineries off the Gulf of Mexico. Methane hydrate, which is frozen within the permafrost and the frozen ocean off Siberia, will begin to melt if global warming continues to increase at its present rate. If this happens, methane gas, which has a warming effect 21 times more than carbon dioxide will be released into the atmosphere, following which it will be difficult to prevent global warming.[7] In addition, there is a possibility that the crisis may exceed our expectations and fears with a sudden change in the sea current.[8]

End of the Age of Oil Wastage

Our civilization in the twentieth century is characterized by our dependence on the use of oil in the twentieth century; and we are still dependent upon it. Gasoline used to fuel automobiles is a mixture of hydrocarbons from C_6H_{14} to $C_{12}H_{26}$ that are refined from crude oil. Kerosene is made from C10–C15 hydrocarbons and is used as a jet fuel. Diesel fuel (light oil) is made from C10–C20 hydrocarbons, and the heavy oils used to fuel ships are made from longer-chain hydrocarbons. The residue from refined fuels is called coal tar and is used for making roads. Electricity is generated using heat produced by burning coal, oil, and, recently, liquefied natural gas. Crude oil is not used only in the generation of energy, it is also a raw material in the manufacture of plastics. Plastics are light, non-biodegradable, easy to process, economical to use, and were extensively used during the twentieth century. The oil from which petroleum is produced is a fossil resource, and the peak of its production has already passed.[9] It is clearly evident that the abundant use of petroleum figures prominently in the history of the human race when considered from a longer perspective.[10] We can use the oil of OPEC and non-OPEC only for 84 years for 25 years, respectively.[11] These periods were calculated from the mass of oil technically extractable and economically profitable which was divided by the production in a specific year. It is of much significance that the USA and Europe are developing alternative energy sources with no effort spared, not only to ensure the domestic security of energy supplies but also those for military security.

Kyoto Protocol

A number of countries took a concrete step towards implementing measures to counteract global warming by becoming signatories to COP3[12] (Conference of Parties to the United Nations Framework Convention on Climate Change),[13] which was held in December 1997 and was aimed at finding ways to reduce the production of carbon dioxide (Kyoto Protocol[14], 1997). Although initially the value of the Kyoto Protocol was questionable because the United States refused ratification, the requirements for implementation were fulfilled when Russia ratified the protocol in November, 2004, and the protocol came into force on February 16, 2005. On February 27, 2007, 172 countries, including many Asian countries, fulfilled the treaty of the Kyoto Protocol. Each country included in Annex B of the Kyoto Protocol has committed itself to reducing and controlling emissions of greenhouse gases within the assigned numerical target during the first commitment period (2008–2012) (Article 3). Under this protocol, Japan has been requested to reduce greenhouse gases in the first commitment period by 6 per cent, compared with its emissions during 1990. However, neither China nor India where industrialization is advancing rapidly is included in Annex B. Moreover, the Southeast Asian countries, with abundant biomass resources are also not included. The framework of a post-Kyoto Protocol was first discussed at COP10[15] in December, 2004. The post-Protocol included the participation of the USA and developing countries such as China, where rapid increase in emissions is expected to be a major threat.

Land-based biomass amounts to 1.8 trillion tons, corresponding to a 33000 × 10^{18} J of energy of (*Biomass Hand Book, 2005*). This is 80 times the annual energy consumption of the entire world. Biomass is a promising resource because products derived from it could possibly replace petroleum. Biomass consist of renewable resources that fix the energy from the sun. The energy from the sun is 620 × 10^{18} J per hour. An important point in the Kyoto Protocol is to encourage the development of energy production from renewable resources (Article 2.1. (a)[iv]).

The use of biomass contributes to reducing the amount of carbon dioxide in greenhouse gases. Methane and fluorocarbons, as well as carbon dioxide, are components of greenhouse gases. However, even the use of biomass may lead to environmental destruction if it is harvested at a greater rate than it is produced. The amount of energy that can be produced from biomass contributes to the control of carbon dioxide emissions in the short term, and poly (lactic acid), a form of plastic made from biomass, fixes and reduces carbon dioxide.[16] The Kyoto Protocol includes a mechanism called the clean development mechanism (CDM; Article 12). Under this mechanism, the amount of the greenhouse gases' emission reduction achieved by a developed country and a developing country in a jointly executed project is considered part of the reduction achieved by the advanced country. If a country that has biomass technology cooperates with a country where biomass is abundant (as it is in many Asian countries), the former is likely to achieve the target of the Kyoto Protocol whereas the latter would have to acquire the technology from the former country. It is necessary that Asian countries cooperate to work on carbon dioxide reduction, because unlike the USA, no Asian countries have both biomass technology and biomass reserves. Moreover, it is expected that the number of Asian countries on which the carbon dioxide allowance is imposed will be greater in the post-Kyoto Protocol. Then, the adoption of a mechanism (Article 12) whereby two or more countries can jointly achieve the target that the EU has set should also be able to come within the range.

Paradigm Shift

Chemists are advocating a new chemistry that originated from problems arising in the twentieth century. Green chemistry[17] is a new paradigm in chemistry that has spread around the USA.[18] In the field of plastics, during the twentieth century chemists and managers sought to make high-performance plastic products at minimal cost. For example, melamine resin, a thermosetting resin produced by the polycondensation of melamine and formaldehyde has many uses in tableware and other goods used in daily life. However, it was reported that harmful formaldehyde is released when in use.[19] This is a concern being the example of the effect that a product can have on the human body while it is being used. Moreover, because polyvinylchloride is easy to produce at a low price, and despite being hard, it can be softened with plasticizers; over 30 million tons are produced each year in the world. However, dioxin may be generated when it is incinerated[20] and it is being withdrawn from use because of concern about the excessive amount being added to the environment after abandoning the plastics. Safety in the production process is also a problem. Polycarbonate, consisting of bisphenol. A moieties bonded by ester bonds, has many excellent properties, such as heat resistance, high impact strength, size stability, and high transparency, and is widely used as an engineering plastic to make DVDs, car parts, electronic devices, OA apparatus, and many other items. However, because phosgene, which is highly poisonous, is used in the production process, this process is no longer in use. A process not using the phosgene process has now been developed. In this new process, the raw material is dimethyl carbonate, which is produced from ethylene oxide and carbon dioxide.[21] In view of the emphasis on carbon dioxide emission control in recent years, there is now a move to use biomass rather than petroleum products as raw materials for plastics production. A large-scale plant for poly (lactic acid) production has been constructed in the USA, and it is expected that similar plants will also be constructed in Asian countries in the near future. However, it is not only the raw material but also the energy use of the production process that is a problem.[22] Even if biomass is used as the raw material for plastics, the effect of carbon dioxide cannot be controlled if a large amount of petroleum is used in the production process. Thus, it is the aim of green chemistry to minimize the environmental load from the raw material to end disposal.

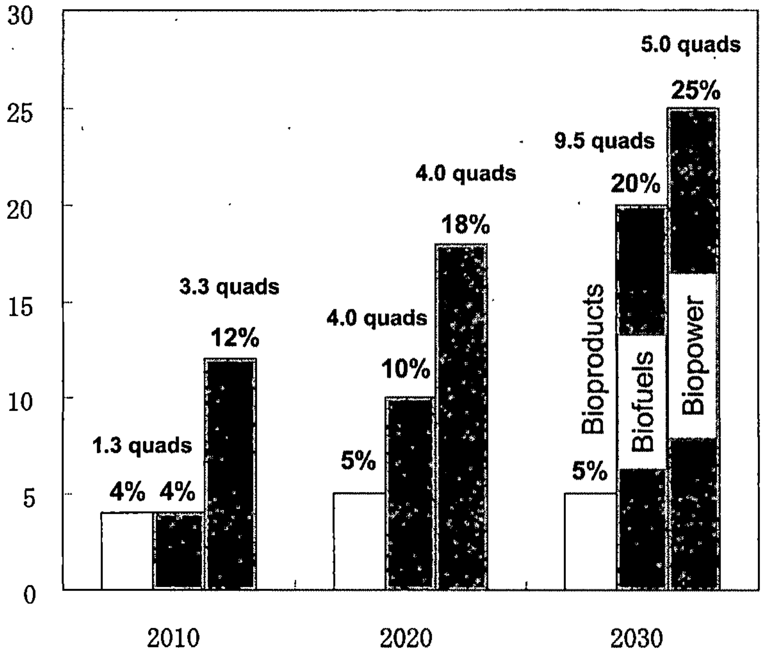
Sustainable chemistry is an environment policy advocated by the Organization for Economic Co-operation and Development (OECD), which has proposed an ideal way for industry to continue to grow while saving resources by recycling and by considering the influence of chemical products on the ecosystem. Furthermore, green chemistry does not include the concept of recycling. The European Chemical Industry Council (CEFIC) and the European Association for Bioindustries (EuropaBio), which receive the support of the Commission of the European Communities, together constitute an organization called the European Technology Platform for Sustainable Chemistry (SusChem), which started in 2004. SusChem facilitates long-term cooperation between governments and the private sector to promote technical improvements for use by governments, industry, the research community, and investors, through advances in three fields: industrial biotechnology, including the search for new enzymes and microorganisms; materials technology; and reaction and process design.[23]

Biotechnology is symbolized by three colours in Europe: red, green, and white. Red, the colour of blood, indicates biotechnology applied to medicine; green, the colour of plant, biotechnology in agriculture; and white, the colour of innocence, is technology as applied to the industry. White biotechnology is also called industrial biotechnology, and has been used since ancient times for making wine, cheese, etc. The term 'white biotechnology' has recently come to be applied more widely, to include the development of genetic techniques. Market analysts predict that white biotechnology will have an economic effect of 11–22 billion euros per year in the chemical industry by 2010, create new employment in many fields, and will stimulate economic activity, and will decrease the load on the environment.[24]

Biorefinery in the USA

Industrial processes using biomass as a raw material are also in the USA. An official announcement was made in August 1999 by President Bill Clinton in an Executive Order[5] for developing and promoting biobased products and bioenergy through biotechnological means to be documented in a report on methods of tripling the use of biomass in the USA by 2010. President Bush applied the idea (Figure 1) to industrial production using biorefineries in October 2002[25] (Abraham, 2004). Moreover, the US Department of Energy (DOE)[26] in deciding the start of a biomass programme announced that 12 chemicals would become the key compounds (building blocks) of a biorefinery (Table 1). The US Department of Agriculture (USDA) assumes that production of ethanol from corn fibre or corn stover will be the first model of biorefinery. Biobased platform intermediate chemicals can be competitively produced by fermentation, the two most well known examples being lactic acid and succinic acid. A third building block, 3-hydroxypropionic acid, a platform intermediate (Figure 2) that can be produced at a theoretical yield of 100 per cent from glucose is being developed.[27] The US Department of Energy's. National Renewable Energy Laboratory (NREL) has teamed up with a commercial partner to design a biorefinery that will use corn or other renewable resources to produce fuels and chemicals such as 1,3 -propanediol that can be used in place of petroleum in the manufacture of textiles, carpeting, and packaging materials.

Figure 1: Vision Goals for Bioenergy and Biobased Products



Note: Bioproducts represents the proportion of target chemicals that are biobased. The column labeled Biofuels represents the proportion of demand for transportation fuels. Biopower represents the proportion of electricity and heat demand in utilities and industry that is supplied by biomass. The quad is an energy unit based on the British thermal unit (BTU, 1 kWh). 1 quad = 1 quadrillion BTU (10^{24} BTU).

Table 1: Top 12 Chemicals that can be Produced from Plant Sugars

Succinic acid	2,5-Furandicarboxylic acid
3-Hydroxypropionic acid	Aspartic acid
Glucaric acid	Glutamic acid
Itaconic acid	Levulinic acid
3-Hydroxybutyrolactone	Glycerol
Sorbitol	Xylitol

The production of ethanol and the addition of motor gasoline have accelerated. President George W. Bush announced a programme called "Twenty in Ten: Strengthening America's Energy Security" in his State of the Union Address in January, 2007.[28] This programme requires that the production of biomass energy from renewable resources should be increased to 35 billion gallons and that the amount of the gasoline used should be reduced by 20 per cent by the year 2017. As alternate fuels, ethanol, biodiesel, methanol, butanol, and hydrogen have been listed, amongst others. However, the effect of ethanol in reducing carbon dioxide emissions in the USA is low. The ratio of the amount of fossil energy used to the amount of produced ethanol energy is only 1.5 for the US compared with the corresponding ratio of 8 for ethanol production from sugarcane in Brazil. In the USA, the energy source is natural gas; in Brazil ethanol is distilled using the combustion heat of bagasse, the residue left after refining sugarcane.[29]

Moreover, in the corn belt of the USA 10 t/ha or more of soil continues to be lost each year as a result of erosion by the action of wind and rain.[30] In addition, there is concern that stable corn production might not be sustainable in the long term because of decreasing groundwater caused by too much irrigation. It seems that the aim of the biorefinery policy in the USA is to develop the use of corn and decrease dependency on oil from the Middle East. In the future, this policy may lead to a food crisis because of diversion of production towards fuel for cars in this advanced country.

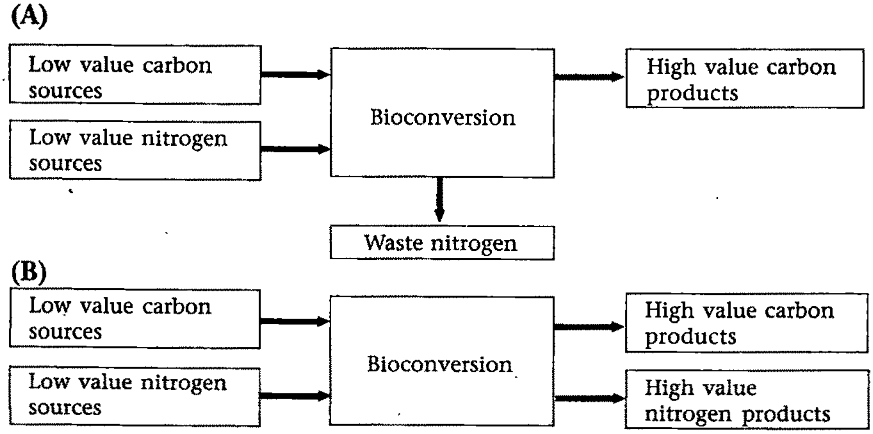
"Cycle C" and "Cycle N"

One of the problems faced by the bioindustry is that of dealing with microorganisms after they have been used in bioconversion. Unlike chemical catalysts, growing microorganisms are problematic and it is considered that microorganisms should not be allowed to grow indefinitely. Therefore, a technology has been developed to immobilize microorganisms and to control their growth.[31] Since refined raw materials are used in laboratories and in factories making products of high when added value such as medicines, a nitrogen source is necessary as a submaterial. However, if using a raw material in high purity for multipurpose bioplastics, the product cost may not be feasible compared with oil-based plastics. Moreover, if the raw material was refined the nitrogen source might be the waste during the refining process. This waste would pollute the environment. A good example is in alcohol fermentation from sugarcane wherein the nitrogen source in molasses is anabolized when the yeast is growing. In this reaction, the removal of the nitrogen source included in molasses and controlling the growth of yeast is not preceded, because the process cost increases.

Humans obtain their essential amino acids, which cannot be biosynthesised in the body, mainly from livestock. However, feeding grains to livestock is an inefficient means of producing essential amino acids. When the population increases and the supply of essential amino acids declines, a more efficient nitrogen circulation process will be required. The author proposes the commercialization of the microorganism used for bioconversion as a high-value-added nitrogen product in biorefinery (Fig. 2).

In conventional bioindustry, low-value carbon sources are converted to high-value carbon by bioconversion (microorganisms). As the microorganism becomes waste, the amount of nitrogen sources

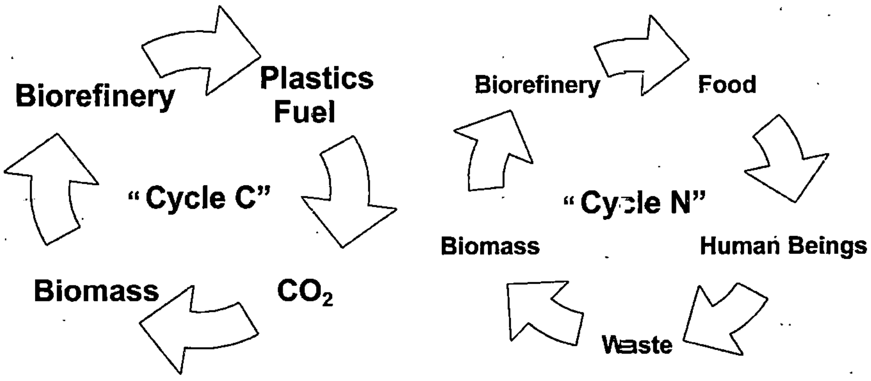
Figure 2: Concept for Conventional Bioindustry (A) and New Bioindustry (B)


(A)
Low value carbon sources
Low value nitrogen sources
Bioconversion
High value carbon products
Waste nitrogen
(B)
Low value carbon sources
Low value nitrogen sources
Bioconversion
High value carbon products
High value nitrogen products

should be minimal. However, it is adequate for such medicinal use, etc. that use refined raw materials. On the other hand, the new concept should be applied to produce fuel and plastics from biomass. These raw materials will not be highly purified, and the nitrogen source will be converted to high-value products.

Bioplastics and ethanol that are now being developed are countermeasures to increasing the carbon dioxide and the oil dryness. This is the plan for making a carbon cycle ("Cycle C"). Feeding grain to livestock is an inefficient means of generating essential amino acids, and as the population increases and essential amino acids run short, a more efficient nitrogen circulation process will be required. The microorganism used for bioconversion is a good source for quality protein wherein it is possible to build the "Cycle N" (Fig. 3).

Figure. 3 Carbon Cycle ("Cycle C") and Nitrogen Cycle ("Cycle N"). Energy and Plastics come under "Cycle C"



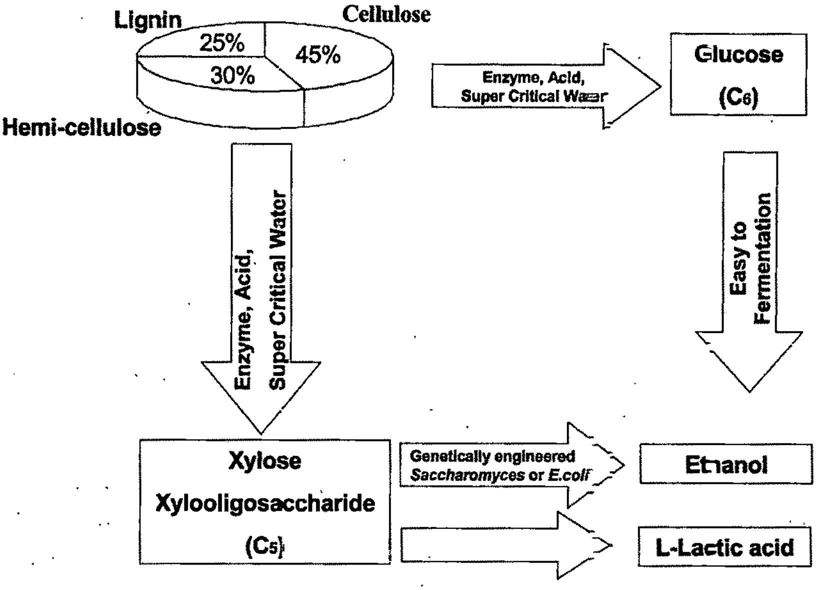
Four Types of Biorefineries

Biorefinery is classified according to the raw material used in whole-crop biorefinery, green biorefinery, and lignocellulose feedstock biorefinery.[32] In whole-crop biorefinery, the raw materials used are cereals such as rye, wheat, triticale, and maize. There are many biomass resources in Asia. Cassava, a kind of potato, contains 25–30 per cent starch. Its country of origin is South America but it now is produced in many countries; the annual world production is 176 million tons, and 50 million tons are produced per year in Asian countries such as

Thailand and Indonesia. The sago palm is another example being a perennial plant which accumulates a large amount of starch in the trunk. It grows in Indonesia and Malaysia, and other countries in Asia. It reaches 7–15 m in height and is 30–60 cm in diameter by about 10–15 years, and 500 kg of starch can obtained from one tree. Although there are no accurate statistics on total production, it is expected that in the near future, there will be 20 million tons or more of undeveloped resources. Because a plantation of sago palm has been developed and grown in Malaysia and Indonesia in recent years, it is considered as a stable biomass. World production of sugarcane further is huge—it was 290 million tons in 2002 in comparison to wheat production which was 570 million tons in the same year. Sugarcane contains about 12 per cent sucrose. Brazil accounts for 28.0 per cent of world sugarcane production, and production from Asian countries accounts for 43.5 per cent of the total.[33]

For green biorefineries, the raw materials are green biomass such as grass from the cultivation of permanent grassland; closure fields; nature reserves; and green crops such as lucerne, clover, and immature cereals from extensive land cultivation. For lignocellulose feedstock biorefinery, the raw material is mainly plant cell walls. The industry that is most advanced in the use of lignocellulose is the pulp and paper industry.[34] Recently, methods of resolving lignocelluloses into syngas and of converting them into sugars that can be fermented to useful chemicals have been developed.[35] Lignocellulose, the major source reservoir of fixed carbon in nature, has three major polymers: cellulose, hemicellulose, and lignin. Various pretreatment options for lignocellulose are now available to fractionate, solubilize, hydrolyze and separate cellulose, hemicelluloses, and lignin components. Hemicellulose includes glucans, mannans, and xylan. The amount of xylan varies in different plants, from as much as 35 per cent of the dry weight of birch wood to as little as 7 per cent in some gymnosperms.[36] Ethanol made from biomass by fermentation is already being used for automobile fuel. Because *Saccharomyces*, typical yeast, cannot utilize xylose, genetically engineered strains of *Saccharomyces*[37] and *Escherichia coli*[38] were developed for converting xylose contained in biomass to ethanol. On the other hand, L-lactic acid can be produced from ligincellulolytic biomass which is the raw material used in xylose fermentation (Fig. 4).[39] Lignocelluloses also can be used as an energy source in biorefinery.

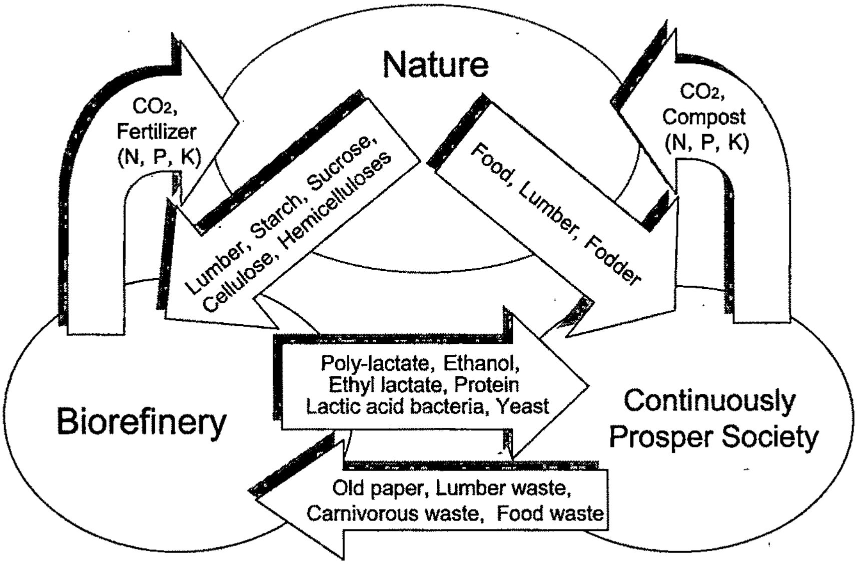
Figure 4: Effective Utilization of Wooden Biomass


Lignin
Cellulose
25%
45%
30%
Hemi-cellulose
Enzyme, Acid, Super Critical Water
Glucose
(C6)
Enzyme, Acid, Super Critical Water
Easy to Fermentation
Xylose
Xylooligosaccharide
(C5)
Genetically engineered *Saccharomyces* or *E.coli*
Ethanol
L-Lactic acid

The fourth type of biorefinery uses organic waste as a raw material.[40] The previous three types of biorefineries are used in countries where biomass is abundant. These countries are set to revive the industry by using agricultural products conforming to agricultural and industrial policies relating to biorefinery. On the other hand, Japan and some European countries lack space for garbage landfill, and have an insufficient area for compost and few agricultural products. Use of biorefinery serves two roles: that of refuse disposal, and, that of the production of useful products.[41] In these countries refuse disposal and environmental pollution policies are interconnected. Old paper, lumber waste, and animal and food waste provide the raw material for fermentation and energy resources (Fig. 5).

In Japan, every year the food industry discharges six million tons of organic waste and ordinary families discharges 10 million tons of garbage. Although this garbage is incinerated or buried underground, organic waste contains excess water and cannot be incinerated. Moreover, when the waste is disposed off in landfills, it also generates methane gas which causes global warming.[42] Laws such as the Food Recycling Law [2001] and the Construction Materials Recycling Law

Figure 5: Relationships among Nature, a continuously Prospering Society and Biorefinery


Nature
CO2, Fertilizer (N, P, K)
Lumber, Starch, Sucrose, Cellulose, Hemicelluloses
Food, Lumber, Fodder
CO2, Compost (N, P, K)
Biorefinery
Poly-lactate, Ethanol, Ethyl lactate, Protein Lactic acid bacteria, Yeast
Continuously Prosper Society
Old paper, Lumber waste, Carnivorous waste, Food waste

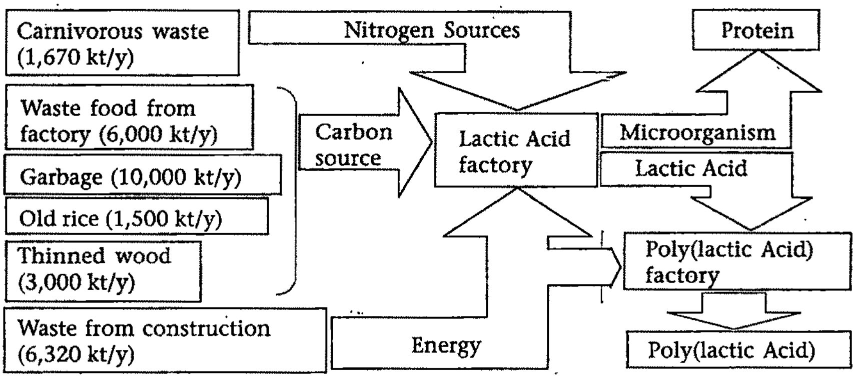
[2000] to recycle food and construction materials wastes (Figure 6) have already been enforced in Japan. Construction materials wastes are used raw materials for the manufacturing energy for production of poly(lactic acid) can be obtained.[43]

Old paper, lumber waste, animal waste, and food waste provide the raw material for fermentation and energy resources.

Ethanol-Poly (lactic acid)-Based Biorefinery

The concept behind biorefineries is the same irrespective of the kind of raw material used. Environmental destruction is the end result of contemporary science based on reductionism. We need to develop holistic science and technology, if we are to achieve a society that strikes a balance between the intricate systems of nature. This is an important proposition for all scientists and engineers. Reductionism assumes that the sum total of the maximization of a partial profit is equal to the maximization of the total profit that caused the environmental destruction; therefore, in this century it is necessary to develop a chemistry that considers influences on the global environment in a holistic way. Nature has been considered as not a reduced system but as

Figure 6: Japanese-type Biorefinery


Carnivorous waste (1,670 kt/y)
Nitrogen Sources
Protein
Waste food from factory (6,000 kt/y)
Carbon source
Lactic Acid factory
Microorganism
Lactic Acid
Garbage (10,000 kt/y)
Old rice (1,500 kt/y)
Thinned wood (3,000 kt/y)
Poly(lactic Acid) factory
Waste from construction (6,320 kt/y)
Energy
Poly(lactic Acid)

an overall system. That is, it is necessary to adopt the idea of using waste (by-products) in the process of producing target compounds, and for this purpose to choose some key materials and produce them efficiently. The problem with industry of the twentieth century was not simply that it relied too much on oil. It is because industry used production systems that were based on such reductionism.

First, alcohol as a fuel for cars is produced using biomass that would globally replace oil. In Japan, about 40 per cent of oil is used in thermal power plants, 40 per cent for transportation, such as cars, and 20 per cent for the manufacture of raw materials and plastics, etc. Then, proposed here is an ecosystem based on a holistic view.[44] The lactic acid fermentation and ethanol fermentation would be the based of this biorefinery. Ethanol produced by ethanol fermentation is used as fuel for cars, etc. Lactic acid produced by lactic acid fermentation is polymerized to form poly(lactic acid), which is used to make plastics. Lactic acid and ethanol are esterified to produce ethyl lactate, which is used as a biodegradable solvent. The demand for ethyl lactate has expanded to provide a replacement for chlorofluorocarbons as the washing solvent for semiconductors. Poly(lactic acid) is produced from L-lactic acid, since available as a food product. However, D-lactic acid will also be produced as a stereo complex polymer.[45] Unlike in chemical synthesis, in this biorefinery microorganisms can easily produce the L- or D-isomer at high optical purity. Although a lactic acid bacterium is usually used[46], *Rhizopus oryzae*[47] and a Bacillus sp.[48] produce lactic acid which is usually produced through

P32015

the use of lactic acid bacteria. Whether the L- or D-isomer is used, lactic acid at high optical purity is required to produce crystalline poly(lactic acid) that is to be used to make fibre or film materials. In polymerization and the chemical recycling processes, lactic acid is racemized by a heating process. Ethyl lactate production is an effective use of the racemized lactic acid. These products play a role in circulating carbon. The yeast and lactic acid bacteria used for the fermentation of ethanol and lactic acid are excellent protein resources for humans. Heterolactic acid bacteria, which can produce lactic acid and ethanol simultaneously, will attract attention in the future. Yeast extract is a good medium component for lactic acid fermentation. These microbes have a high degree of safety since they have long been used in fermented food products. In other words, this process plays a role in circulating nitrogen. In addition, enzymes, probiotics, lactic acid bacterial inocula for silage and useful physiologically active materials such as bacteriocin can be produced from lactic acid bacteria.[49] When a *Bacillus* species is used, an insect pathogen can also be made simultaneously with lactic acid.[50] Since many useful products are obtained in this way in the production process, poly(lactic acid) is suitable for use in a biorefinery. Fermentation cultures using ethanol, lactic acid, and microorganisms are applied to fields as fertilizer, and the phosphorous and potash are then circulated. In this way, not only does wastewater treatment become unnecessary but also fermentation waste can be sold as a product. Poly (3-hydroxybutyric acid), biodiesel oil from rapeseed oil or palm oil, hydrogen, and methane from biomass are other potential biorefinery products.

From the point of view of business feasibility, many products form the so-called product portfolio and profits from fast-growing products can be invested in the development of the next products to show promise.[51] Markets for food additives, lactic acid and brewing ethanol are already established, and yeast and lactic acid bacteria are used as feeds. Although expansion of these markets has stopped, markets for fuel ethanol and for ethyl lactate, which is used as a solvent, are expanding rapidly, and poly(lactic acid) also has a large potential market. As high-value products, physiologically active materials contribute to the stability of enterprises, and microbial proteins are a promising future profit source. Since establishing a biorefinery is a large undertaking, the participation of many companies and national cooperation are required.

Conclusion

Nobody would object to the opinion that the first half of this century constitutes an age of environmental science. Chemistry that uses biomass as its raw material will develop in this century, unlike the twentieth century, when industry was able to use oil in abundance. Plant genetics, biochemistry, biotechnology, biomass chemistry, and separation and process engineering synergize each other.[52] In the twentieth century we began to turn our focus away from the limited fossil resources. However, if depletion is faster than the production, it is clear that it will completely be used, despite the biomass being a renewable resource. Developing Asian countries should not repeat the mistakes made by Europe and the USA in the twentieth century. There is a philosophical problem underlying environmental problems. There is a Western concept of trying to deal with nature on the basis of the science of the twentieth century. If an attempt is made to maximize the accumulation of partial happiness, the negative part generated by the process will be rounded down. We should learn from nature that it is a complex system. There is no wastage in nature—everything circulates. Nature has a food chain and a circulation system, and no specific product is treated as waste. The control of the system works even in the case of an imbalance by generating a large volume of a specific product, following which the system assumes a constant environment. This idea is familiar in the many Asian countries where harmony with nature has always been respected. Biorefineries based on this thought will become part of nature. Thus, the final goal should be to construct biorefineries that would integrate with the nature

Endnotes

[1] The Intergovernmental Panel on Climate Change (IPCC) has been established by WMO and UNEP in 1988 to assess scientific, technica and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. The IPCC doesnot carry out research nor does it monitor climate related data or other relevantparameters.

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[5] Godoy (2006).

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[9] Heinberg (2005).

[10] Henderson (1996).

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[12] Third Session of the Conference of the Parties (COP3) to the U.N. Framework Convention on Climate Change, December 1-10, 1997, Kyoto, Japan.
  - Tenth Session of the Conference of the Parties (COP10) to the U.N. Framework Convention on Climate Change, December 6-17, 2004 Buenos Aires, Argentina.
  - Documents concerning all COP sessions could be obtained from the UNFCCC Secretariat (http://unfccc.int/secretariat/items/1629.php)

[13] The United Nations Framework Convention on Climate Change (UNFCCC) sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The Convention enjoys near universal membership with 191 countries having ratified it. Under the Convention, governments:
  - gather and share information on greenhouse gas emissions, national policies and best practices,
  - launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries,
  - cooperate in preparing for adaptation to the impacts of climate change. The Convention entered into force on 21 March 1994.

[14] The Kyoto Protocol! The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions. Only Parties to the Convention that have also become Parties to the Protocol (i.e. by ratifying, accepting, approving, or acceding to it) will be bound by the Protocol's commitments. 173 Parties have ratified the Protocol to date. Of these, 35 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5 per cent from 1990 levels in the commitment period 2008-2012. The Kyoto Protocol entered into force on 16 February 2005.

[15] Third Session of the Conference of the Parties (COP3) to the U.N. Framework Convention on Climate Change, December 1-10, 1997, Kyoto, Japan.
  - Tenth Session of the Conference of the Parties (COP10) to the U.N. Framework Convention on Climate Change, December 6-17, 2004 Buenos Aires, Argentina.
  - Documents concerning all COP sessions could be obtained from the UNF CCC Secretariat (http://unfccc.int/secretariat/items/1629.php).

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Biorefineries: A Contribution to the Human Face of Biotechnology

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Abstract: Plant matter represents a huge quantity of a renewable resource called biomass, which is the most important bioresource to sustain life on this planet. The question then arises of how nature is able to cope with an increasing human population, which automatically results in a higher animal population and demands for food, feed, energy and commodity products. Sustainability can be obtained together with higher health and living standards, if appropriate technologies are applied by the local society. As the value of the biomass content is related to the chemical and physical properties of large molecules, the challenges for the future are to be found in a combination of the biological, physical and chemical sciences to replicate an 'oil refinery' with a 'bio-refinery' thus replacing finite non-renewable fossil resources with biorenewable biomass resources for the production of food, feed, fertiliser, fuel, energy, industrial chemicals and related consumer products through the use of clean and green bioprocess technologies. In Asia several countries have embarked on this path of bioeconomic development and growth.

Keywords: Biorefinery, Biotechnology, Biofuel, Biodiesel, Biogas,Composting, Environmental Conservation, Ethical Concerns, Mushroom, Renewable Energy, Silage, Syngas, Thermochemical Energy, Waste Management, Poverty Restriction.

Introduction

Biotechnology, notwithstanding its dark side, has now been accepted as one of the four new empowering technologies essential for bioeconomic advancement and long-term sustainable development for at least the next five or six decades. Rich and rooted in traditional biotechnologies like the age-old dairy and food fermentations, biotechnology can make a significant contribution towards the unveiling of its human dimensions in efforts to curb the onslaught of poverty, improve the welfare of men, women and children —the primary investors and practitioners of rural biotechnology. Furthermore, it can build immunological firewalls against the intrusion of inimical entities that erode valuable indigenous and skilled human resources, and that gives the much needed substantive and tangible push to the development of the bioentrepreneurial spirit.

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> *"The fuel of the future is going to come from fruit like that sumac*[1] *out by the road, or from apples, weeds, sawdust — almost anything," he said. "There is fuel in every bit of vegetable matter that can be fermented. There's enough alcohol in one year's yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for a hundred years."*
>
> ——*Henry Ford*[2]

In this context, biorefineries are particularly important for developing countries that use a combination of "old and modern" techniques for the improvements in the health and living conditions of 80 per cent of the world's population. For centuries humankind has used microbial intervention to sustain its agricultural and food systems in the maintenance of human health and welfare. As long as the development of biotechnology is driven only by commercial enterprise, human development will lag increasingly behind. Sustainable development and human development are closely related and cannot go into separate directions.

> *"The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time". The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which use it."* 1911/ 1912
>
> -Rudolf Diesel, 1912[3]

The geo-economic landscape and the geopolitical equation of the world are undergoing rapid changes driven by the emergence of new economic groups and markets enriched by the availability of genetically engineered products. The new driving force in the novel geopolitical equations of biotechnology can be found particulary in the southern hemisphere that has an abundance of biorenewable resources which gives significant meaning in the distinction between the twentieth century [the era of a finite petroleum-based economy that evolved from the use of fossil fuels, i.e. buried combustible deposits of organic materials, formed within the framework and pressure in the earth's crust into crude oil, coal, natural gas, or heavy oils, and the twenty first century which is beginning to see the use of biorenewable resources within the framework of short biological time that uses microbial enzymatic power, photosynthesis and specialized genetic engineering techniques to embark upon the constancy and consistency of a carbohydrate-based economy.

Oil Crops in South Asia with Potential for Biodiesel Production

Non-edible oils from plants such as: Jatropha, Karanj, Neem, and Kusum are being researched to supplement traditional highly polluting fuels and to provide employment for landless and marginal people. These plants that grow in low-rainfall areas are fast-growing, hardy, are rejected by browsing cattle and goats, and contain about 25 to 40 per cent of an oil that needs virtually no engine modification when esterified and blended with diesel. Moreover, the residual oil cake is rich in minerals and organic residues, which constitutes an excellent fertiliser as well as serves as a good soil-binding material.

Plant oil is highly valued as a source for Bio fuel 'Diesel' Bio Diesel refers to a diesel-equivalent, processed fuel derived from biological sources.[4] As a processed fuel it can be readily used in diesel-engined vehicles, which can distinguish biodiesel from the straight SVO or waste vegetable oils (WVO) used as fuels in some modified diesel vehicles. Biodiesel can also be used as a heating fuel in domestic and commercial boilers. Plant oils are of two types – (i) non-ediblie oils, and (ii) edible oils (Table 1). Other significant plant oils include: castor oil, coconut oil, corn oil, hazelnut, mustard oil, radish oil, ramtil oil, sesame oil, and tung oil.

In China *Jatropha curcas* is mainly distributed in the hot-dry valley areas of Yunnan, Sichuan, Guangxi, Guangdong and Hainan. In Yunnan some 33 thousand hectares are covered with Jatropha forest providing economic incentives to embark on the development of biodiesel as an alternative source of energy. *Jatropha curcas* grows abundantly in several Indian states. Over eighty different species of

Table 1: Non-Edible and Edible Oils Possessing Biodiesel Potential

Type	Oleaginous Plant Sources	Remark
Non-edible oils		
Copaiba	An oleoresin tapped from the species of the genus *Copaifera*. Used in Brazil as a major source of biodiesel	Used in Brazil as a major source of biodiesel
Honge oil	Obtained from derived from *Pongamia pinnata*	Pioneer research in India for use as a biofuel
Jatropha oil	Notwithstanding that over 80 species of the Jatropha plant are known the species *Jatropha curcas* is mostwidely used	Widely used in several Asian countries south and southeast countries as a biofuel oil and is the base fuel in serving the rail, automobile and rural sectors; large-scale Jatropha-based biodiesel plants planned in India.
Jojoba oil.	Extracted from *Simmondsia chinensis*, a desert shrub	Not widely used in Asia but as potential for development as a supplementary bioenergy source in desert areas of China, India and Central Asian countries
Milk bush	*Synadenium granti* from the family *Euphorbiaceae* is a poisonous plant widely found in Africa	Investigated by PetroBras, the Brazil as a possible source of biofuel
Petroleum nut oil	*Pittosporum resiniferum* from the family *Pittosporaceae*	The nut a native to the Philippines was found to be financially not feasible for exploitation as a biofuel following governmental research studies some two decades ago
Edible oils		
Cottonseed oil	*Gossypium herbaceum*	A major food oil, often used in the industrial food processing
Palm oil	*Elaeis guineensis*	The most widely produced tropical oil which is also used to make biofuel
Olive oil .	*Olea europaea*	Used in cooking, cosmetics, soaps and as lighting fuel for traditional oil lamps
Peanut oil	*Arachis hypogaea*	Flavoured cooking oil
Rapeseed oil	*Brassica napus*	One of the most widely used cooking oils; also popularly known as canola
Soybean oil	*Glycine soja*	About half of the worldwide edible oil production is met by soybeanoil
Sunflower Seed oil	*Helianthus annuus*	A common cooking oil

the Jatropha plant are also encountered as potential biodiesel sources.

In India, Karanj or the pongam tree has the rare property of producing seeds of 30-40 per cent lipid content. The seed oil is an important asset of this tree having been used as lamp oil, in soap making, and as a lubricant. It is of especial significance as it is one of the few crops well-suited for commercialisation by India's large rural poor population. Several unelectrified villages have recently used Honge oil derived from *Pongamia pinnata* to fuel their diesel generators, and to create their own grid systems to run water pumps and electric lighting. Recently, the seed oil has been found to be useful in diesel generators and along with Jatropha it is being explored throughout India as a feedstock for biodiesel. The feasibility of the Neem (*Azadirachta indica*) oil seeds for production of biodiesel as well as power in the state of Karnataka is being assessed. Similarly, Kusum (*Schleichera oleosa*) is being tested for it potential use in the production of biodiesel.

Biodiesel[5] is an alternative to the petroleum-based diesel fuel and is made from renewable resources such as vegetable oils, animal fats or algae. It is a fuel comprised of a mix of mono alkylesters of long chain fatty acids. A simple transesterification production process is used to convert the base oil to the desired esters and to remove free fatty acids. Unlike straight vegetable oils (SVO), biodiesel has very similar combustion properties to petroleum diesel, and can replace it in most current uses. However, it is most often used as an additive to petroleum diesel. In summary, biodiesel is renewable, non-toxic, clean and biodegradable. Studies in Germany have shown that the substitution of fossil fuels by locally produced renewable energy contributes to an improved trade balance. Furthermore, some 15 jobs per 1000t of biodiesel production were created. A wide variety of biodiesel fuels are in use throughout Asia and the Pacific (Table 2).

Bio-Refinery Concept and Platforms

A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass.[6] The biorefinery concept is analogous to today's petrorefineries, which produce multiple fuels and products from petroleum oil (Figure 1).

Industrial biorefineries have been identified as the most promising route to develop a new domestic bio-based industry. By producing multiple products, a biorefinery can take advantage of the differences

Table 2: Types of Biodiesel Biofuels used in Asia and the Pacific

Country	Activity/Goal	Socio-economic and Human benefits
ReBionewable Resource: Jatropha ***curcas* -*Family Euphorbiaceae***		
Cambodia	Biofuel for Rural Sustainable Development and Poverty Alleviation through Cambodia / Canada, and French NGO collaboration with focus on: poverty restriction; conservation of the rural environment through reduction in use of diesel fuel; promotion of the rural aesthetics and cultural dimensions of village life and long-term economic sustainability. Provide through Cambodia/Australia collaboration via the Maharishi Vedi University (MVU) - Cambodia's only rural university opportunities for rural youth who lack normal access to higher education with government recognized undergraduate degrees in agriculture and management.	- Nw source of income and job opportunities for women householders; biofuel oil to be sold locally to provide water pumping, battery charging and electricity services; seed cake to be used as fertiliser - Design, build, and operate a small, self-sufficient a MVU bio-diesel production facility using waste vegetable oil and plant oil that will directly contribute to the development and campus of MVU local market needs and surrounding communities. - Creation of a model of decentralized sustainable energy production for replication throughout Cambodia.
India	Jatropha cultivation has been selected by the Indian government as a renewable energy source to provide an alternative fuel – biodiesel for the future.-Jatropha plantations have been initiated or planned in the Indian states of Andhra Pradesh, Chhattisgarh, Gujarat, Haryana, Kerala, Maharashtra, Rajasthan, and Tamil Nadu.[7] - The Tamil Nadu Agricultural University operates a Pilot Plant for biodiesel production with a capacity of 250 litres / day.- The Indian Railways has started to use the Jatropha plant oil (blended	- Employment opportunities to the rural poor as a means to attain local and national energy independence. - Opportunities for small business enterprises to be developed through R&D activities and support for developing alternate biorenewable energy resources. - Indian Government promotes alternative bioenergy initiative in using cleaner transport fuels.

Table 2 continued

Table 2 continued

Country	Activity/Goal	Socio-economic and Human benefits
	with diesel fuel in various ratios) to successfully power its diesel engines. The rail line between Mumbai and Delhi is planted with Jatropha and the train itself runs on 15-20 per cent biodiesel.	
Indonesia	Directorate of Estate Crop Development, Directorate General of Estate Crop, Jakarta, 2005 proposes 'Development of *Jatropha curcas* plantation as source raw material biodiesel with aims to: - reduce import of petroleum; create opportunities for employment in the national labour market; enhance the security of biodiesel supply and conserveforeign-exchange earnings; and develop the plantation area of eastern Indonesia. - National Seminar on Biodiesel: *Jatropha curcas* - Development for Biodiesel and Burning Oil organized by Institute Pertanian Bogor (IPB), Bogor, 2005, to promote private and public consultations within framework of the theme 'Biotechnology for the Welfare of the People'.	- Jatropha found in the in the islands of Flores, Java, and non-eastern Timor are used to create living border fences; produce ornamentals; prepare medicinals; and provide domestic fuel for lighting.
Laos	Promotion of sustainable development and agroforestry through project focus on: development of investment opportunity in the production of biodiesel from Jatropha curcas plantations in the Sang Tong District at the National Agricultural Research Centre, Vientiane in collaboration with the private sector and an NGO in collaboration with a licensing company based in Vientiane and the local organic farmers association to use Jatropha as a bioresource to generate electricity for remote villages in Laos.	- Reduction of poverty through farmers' involvement in programmes of reforestation with *Jatropha curcas* using thisto produce biodiesel as a suitable substitute for fossil-diesel consumption; and to use the seed cake as soil binding and fertiliser material. - Set up with the Ministry of Agriculture and farmers in the Saythany district, Vientiane, Jatropha 'biodiesel' Saythany district, Vientiane, Jatropha 'biodiesel' nurseries to promote biodiesel business and by-products operations.

Table 2 continued

Table 2 continued

Country	Activity/Goal	Socio-economic and Human benefits
Nepal	Through Nepal/UK collaboration and at Tribhuvan University, Kathmandu provides 'hands-on action training' in the propagation, establishment and cultivation of an additional 120,000 oil-bearing plants on marginal lands, in harvesting of seeds from mature plants in the Tanuhun District to reduce the dependence of the Nepalese economy on imported oils, fuels and chemical fertilisers in cooperation with the Women's Development Section of the Ministry of Local Development in the district.	- Promote and establish the economic empowerment and independence of poor rural women and conserve their health by reducing the drudgery of the poorest women through their involvement in income-generating activities : cultivation and collection of oilseeds, soap production and marketing of oil and by-products such as seed cake residues as soil fertilizer.
Philippines	Plantation of Japtropha trees in military camps and unused land to lessen country's dependence on oil imports.	- Use biodiesel as a suitable substitute in fossil. - diesel consumption.
Sri Lanka	Alternative Resource Income for Women in the Tanamalwila area.	- Promote efforts to engage rural women in sustainable income-generating activities like: production of high quality soap, raw material for cosmetic products and use seed cake residues as soil fertiliser, and fuel for cooking and lighting.
Thailand	Through Thailand/UK collaboration that embraces the Kyoto Protocols Clean Development Mechanism a national biodiesel programme was initiated. Several pilot plants are now operating such as the Royal Chitralada Projects at Raja Biodiesel Co. Ltd in the Donsak District in Surattani Province [and, which was the first established biodiesel plant and pioneer in developing non-fossil diesel fuel in Thailand]; Department of Alternative Energy Development and Efficiency, Royal Naval Dockyard	- Several petrol stations in Bangkok and Chiang Mai distribute B5 biodiesel.-Regional cooperation amongst ASEAN countries was initiated by the Renewable Energy Institute of Thailand and the Asia-Pacific Round Table for Sustainable Consumption and Production as a result of the linkage of the economic corridors between Thailand with Myanmar (Burma), Cambodia, Vietnam, Laos and the southern provinces of China. - In Chiang Rai in the northern most province of Thailand the Khom Loy Development Foundation

Table 2 continued

Table 2 continued

Country	Activity/Goal	Socio-economic and Human benefits
	and the Thailand Institute of Scientific and Technological Research.	with an NGO is funding the plantation of 26000 Jatropha trees within the framework of the Jatropha Biodiesel and Village Development Project that is of environmental and economic significance to the local tribal communities. - Contribution towards capacity-building of the local hilltribe communities' to direct their own future through their involvement in the implementation of the biodiesel project. - Provision of local jobs and income-generating activities for the hill tribe people of Mae Yao sub-district in the reforesting ofdepleted sections of jungle with biofuel plantations.
Vietnam	Vietnam Institute of Ecological Economy and Institute of Tropical Biology promote preliminary study on physic nut (*Jatropha curcas* to produce biodiesel and by-products and to cover wasteland with a green cover and to combat desertification.	- In current use in Vietnam as traditional medicine and hedge borders in: Hoa Binh, Son La, Quang Tri, Ninh Thuan, Binh Thuan, Khanh Hoa, Lam Dong, Dong Nai provinces and Ho Chi Minh City.
Biorenewable Resource: Catfish oil (*Ictalurus punctatus*)		
Vietnam	Seafood processing company aims to clean up pollution of the Mekong Delta through bioconversion of catfish fat into clean biodiesel that has been approved for use by the Vietnam National Institute for Standards and Technology.	- Catfish fat normally used as lubricant and fish feed following its transformation into biodiesel for local cars; and to provide an intermediary glycerine platform for the production of cosmetics, dyeing and pharmaceuticals.
Biorenewable Resource: Coconut oil (*Cocos nucifera*)		
Indonesia	Promote multifeedstock flexibility that involves in later stages the use of coconut and other vegetable oils in biodiesel plants using palm oil as the base biofeedstock.	- Reduction in use of fossil-fuel diesel.

Table 2 continued

Table 2 continued

Country	Activity/Goal	Socio-economic and Human benefits
Malaysia	Promote multifeedstock flexibility that involves in later stages the use of coconut and othervegetable oils in biodiesel plants using palm oil as the base biofeedstock.	- Reduction in dependence on the use of fossil-fuel diesel.
Papua New Guinea	Processing plant established in Bougainville island.	- Used as local automobile biofuel.
PacificIslands	Reduce dependence on fossil-fuel diesel in Pacific island countries.	- Use environmental-friendly coconut oil to minimize pollution. - provide income-generating opportunities for rural island communities.
Philippines	Philippine Coconut Authority launches national program promoting use of coconut oil biodiesel.	- Use biodiesel as a suitable substitute for fossil. - Diesel consumption.
Singapore	Promote multi-feedstock flexibility that involves in later stages the use of coconut and soybean oils and other vegetable oils in biodiesel plants using palm oil as the base biofeedstock.	- Use biodiesel as a suitable substitute fossil-diesel consumption. - Prime distributor of biodiesel in South-east Asian region.
Solomon Islands	Virgin Coconut Oil (VCO) has been in use for several years in a 50/50 diesel/VCO in the Solomon Islands as a biofuel for: a Toyota Hilux 4WD, a Mitsubishi Truck and for tractors	- Environmental friendly non-polluting biofuel that is sediment-free, that give sweeter smell fumes and that allows engines to run smoothly with a minimum of noise
Thailand	Reduction in dependence on fossil-fuel diesel.	Use environmental-friendly coconut oil to minimize pollution. - Provide income - Generating opportunities for rural communities.
Vanuatu	Since 2000, 200 minibuses were running on a coconut / diesel oil mixture.	- Promote economic development in Vanuatu to help sustain rural livelihoods heavily dependent on the coconut crop and its processing.

Table 2 continued

Table 2 continued

Country	Activity/Goal	Socio-economic and Human benefits
Biorenewable Resource: Cotton, Cottonseed Oil (*Gossypium herbaceum*)		
Kazakhstan	Biodiesel plant using cotton and cottonseed oil as base feedstock which will be supplemented later by multiple feedstock flexibility.	- Meet local needs and provide neighbouring EU countries with biodiesel supplies.
Biorenewable Resource: Palm oil (*Elaeis guineensis*)		
Malaysia	A biofuel hub, comprising the Tanjung Langsat Port and a 480ha biofuel park, Johor was set up to cater to the fast growing palm oil-based sector. A strategic move has been made by governmental authorities to refocus the use of palm oil towards production of biodiesel as a response to pressing demand from several European countries confronted by an interruption and insecurity of routine transboundary transport of fossil-fuel supplies that result from political considerations, and the rising prices of fuel. Malaysia has already begun preparations to change from diesel to bio-fuels by 2008, including drafting of legislation that will make the switch mandatory.	- Palm oil is one of the least expensive vegetable oils. - First integrated palm biodiesel plant in the world; and first to commercialize technology for biodiesel production with ancillary benefits in the labour and employment sectors.
Indonesia	A biodiesel plant with a capacity of 250,000 tonnes is expected to come onstream this year in Riau.	As the world's second producer of palm oil opportunities for improvement in the labour and employment sectors are planned to boost economic advancement.

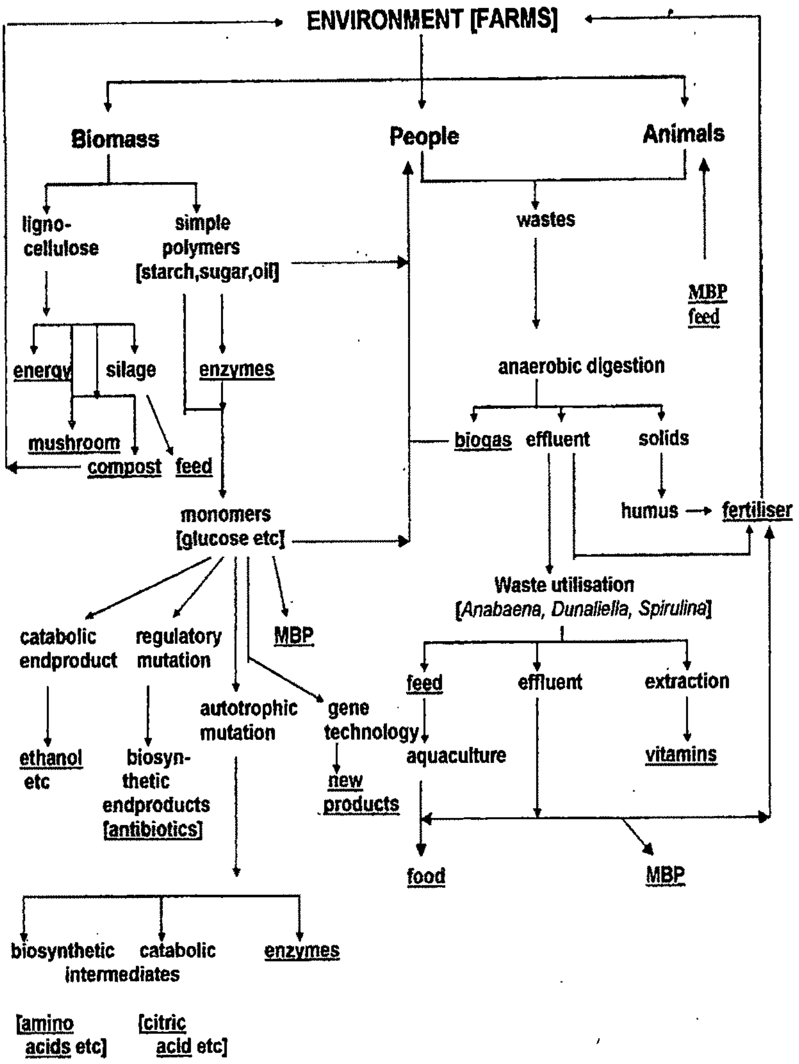
Table 2 continued

Table 2 continued

Country	Activity/Goal	Socio-economic and Human benefits
Singapore	By virtue of its crucial geographical connectivity and *city-state* stature in the global economy and financial markets two biodiesel plants using palm oil as the base biofeedstock in Jurong island which in later stages will be supplemented by multifeedstock flexibility that envisages the use of soyabean and other vegetable oils.	- Both plants—one in cooperation with the biodiesel plant in Darwin, Australia, and the other with a joint Singapore-USA venture will function as a biodiesel hub with ancillary benefits in the labour and employment sectors - The Australia/Singapore venture will be one of the largest producers of pharmaceutical foods and food-grade glycerine which as the glycerol platform has multiple end-use applications in the food and cosmetics industries and in the production of solvents.
Thailand	Daily transportation between the Hatyai district in South Thailand to Sugaikolok district (Thailand-Malaysia border)—a distance of 214 km, using 50per cent biodiesel from stearin palm oil.	- Significant financial savings in use of fossil-diesel fuel. - Plans underway to expand use of biodieselin rail transport.
Biorenewable Resource : Soybean oil (*Glycine soja*)		
South Korea	Biodiesel is an approved B-20 blend biofuel for use in local automobiles.	- Plans are being formulated to issue market soy-bean biodiesel for use by the middle-income class. Biorenewable Resource: Vegetable oils
China	Develop biodiesel as an alternative biofuel to fossil-fuel use by using as feedstock rapeseed oil, cottonseed oil and recycled frying oil; first commercial plant on stream in 2001 (10,000 t/a) with extension in production in 2003 (100,000 t/a).	- Significant financial savings in use of fossil. - Diesel fuel

Source: Compiled by co-author

Figure 1 : The Biorefinery Concept



in biomass components and intermediates and maximize the value derived from the biomass feedstock. A biorefinery might, for example, produce one or several low-volume, but high-value, chemical products and a low-cost, but high-volume liquid transportation fuel, while generating electricity and process heat for its own use and perhaps enough for the sale of electricity. The high-value products enhance profitability, the high-volume fuel helps meet national energy needs, and the power production reduces costs and avoids greenhouse-gas emissions.

Microorganisms and plants are biofactories that derive their transforming power from their inherent powerhouses of enzymatic machinery and symphonies of cyclic and interactive metabolic inputs and outputs. These 'green and clean' biorefineries scientifically referred to as natural cycles of matter are at the basis of biomolecular transformations that contribute to the production of biochemicals, biofuels and biomaterials. These biofactories, using a carbohydrate-based platform, mimic the crude oil fractionates that serve as fossil-based fuel feedstock to produce the vast array of petroleum-based products in use that sustain current styles of living. Bioconversion of plant biomass and agroindustrial residues results a number of industrially useful bio-derived intermediates that give fiscal meaning to the concept of a biobased economy through the use of several biorefinery platforms[8]:

- ***Whole Grain Crop Biorefinery Platform'*** uses raw materials such as barley, maize, sorghum or wheat and in which economically recoverable plant components such as , agro-fibre residues and sugars are then subjected to thermochemical gasification, and to fermentation respectively to yield ethanol[9], other transportation fuels, and other bio-chemical intermediates such as the glycerol and succinic acid intermediate platforms which altogether result in the availability of a wide variety of biobased products and oleochemicals such as biolubricants. Fructose or fructose syrup from starch and sucrose are very important for people with diabetes and can be amongst the various ancillary by-products produced.
- ***The Green Biorefinery' Platform*** uses materials with relatively high water content, such as green grass, used phyto-remediant plants and water hyacinths. Old environmental biotechnologies such as composting and wastewater treatment have been used to accelerate and facilitate the biodegradation of pollutants and the biocleansing of soil and water resources contaminated by uncontrolled weed growth. Phytoremediation, for example, uses plant-based technologies such as phytoextraction, phtyto-stabilisation, phytotransformation and rhizoinfiltration to clean up pollution from sites polluted by metal, oil, and pesticide

deposits and residues in soils and groundwater. Some examples of plants used in phytoremediation practices are water hyacinths (*Eichhornia crassipes*), poplar trees (*Populus* sp.), forage kochia (*Kochia prostrata*), alfalfa (*Medicago sativa*), Kentucky bluegrass (*Poa pratensis*), Scirpus sp., Coon's tail (*Ceratophyllum demersum*), American pondweed (*Potamog nodosus*) and the emergent common arrowhead (*Sagittaria latifolia*). Groundbreaking work in phytoremedation relies on the use of transgenic plants[10] to detoxify metal pollutants such as cadmium, mercury, nickel, and zinc.

- ***The Thermochemical and/or Syngas Biorefinery Platform*** uses thermal processes for gasification of cellulose and lignocellulose from crops as well as black liquor residues from primarily the paper and pulp industry and agro-industrial residues. Thermochemical production of biofuels involves gasification[11] to form synthesis gas, and cogeneration to facilitate the production of heat, alcohols and diesel fuel substitutes. There are four primary classes of biopower systems: direct combustion, cofiring, cogeneration and gasification.
- ***The Biogas Biorefinery Platform*** that uses natural consortia of microorganisms in anaerobic digesters produces methane (natural gas)[12] from decomposing organic material, organic wastes and treatment of manures at animal and poultry feedlots.
- ***The Plant Oil Recovery Biorefinery Platform*** uses the process of transesterification in the treatment of vegetable oils, animal fat, and domestic cooking oils originating from soybean, corn, palm, and canola to yield fatty acid methyl esters commonly known as biodiesel.[13]
- ***The Genetic Engineering Plant Products Platform*** uses selective breeding and genetic engineering to develop plant strains that produce greater amounts of desirable feedstocks or chemicals or even compounds which the plant does not naturally produce, i.e. biorefining takes place in the biological plant rather than the industrial plant.[14] Genetically-engineered plants, shrubs and trees can be developed to produce either high-value chemicals or de novo compounds that are not naturally produced by the non-genetically engineered plants. The production of biobased products other than food and feed derived from bioresources such as agricultural and forestry materials, animal (skins, horns, etc) and

marine (seaweeds) materials have good commercial value (Box 1*a*) and have given rise to established and emerging bioindustries (Box 1*b*).

Box 1*a*: Range of Biobased Products

- **Biofuels**
  - — *solids*: bagasse, lignin residues
  - — *liquids*: biodiesel, ethanol, methanol
  - — *gaseous*: hydrogen, methane
- **Biochemicals**
  - — *agricultural chemicals*: fertilisers
  - — *fuel additives*: metal deactivators e.g. N,N'-disalicylidene-1,2-propanediamine used for gasoline and jet fuels and corrosion inhibitors, e.g. hexamine and phenylenediamine
  - — *industrial surfactants*: wetting agents such as glycols
  - — *intermediate chemicals*: acetic and fatty acids, fuel additives, furfural, phenols
  - — *specialty chemicals*: food esters/emulsifiers and acidulants; botanicals extracts, vegetable oils
- **Biomaterials**
  - — *speciality biomaterials*: absorbents, biopolymers, biodegradable plastics, composite and compressed fibre materials for packing and transportation, dyes, industrial adhesives and gums, inks, oils, ornamentals, paints, pigments and varnishes

Box 1*b*: Established and Emerging Biobased Industries

- **Established Biobased Industries**
  - — Recycled packaging materials from agro-industrial residues
  - — Bioabsorbents for use in odour control, pet litter, animal bedding
  - — Biocement in building, insulation, and road materials
  - — Biocontrol products - soil amendments, fertilisers and pesticides
  - — Biobased products - cellulose-based paints, cosmetics
  - — textiles, and landscape products, e.g. decorative barks, floral ornamentals
- **Emerging Biobased Industries**
  - — Plant-based plastics, starch-based biodegradable polymers, films
  - — Biodegradable soybean oil-derived lubricants, greases-refined fluids
  - — Soybean derived inks and paints
  - — Enzymes—Cellulases for fruit juice clarification and stone-washed jeans —Amylases for nutrition enhancement
  - — Renewable carton packaging materials from bagasse, kenaf
  - — Biochips involving mating of bacterial proteins with silicon chips
  - — Edible vaccines, rub-on vaccines

Source: Adapted from DaSilva (2001).

In principle a biobased product is one that can be derived not only from petroleum but also from biomass. Biobased products in comparison to their petroleum-derived counterparts are non-polluting, environment friendly and sustainable, and do not use substances injurious and toxic to human and animal health. Moreover, such products reinforce rural economies, improve gender equality, and restrict the spread of poverty through provision of new job opportunities and new markets for farm commodities and residues.[15]

Biomass in the form of plants and trees capture solar energy through photosynthesis and stores it as chemical energy in the bonds between the carbon, hydrogen, nitrogen and oxygen atoms that form lignocellulosic plant material together with starchy, sugary, fatty and proteinaceous materials. Biomass is solar energy stored in a chemical form which is available for bioenergy, biofuel, food, feed, fertiliser and many other products formations.

The ultimate goal of each bio-refinery management is to ensure self-efficiency in food, feed, fuel, fertiliser and energy production with marketing products depending on the surplus encountered after the first priority, i.e. improved health standards welfare, has been satisfied.[16] Thus, and for the different categories of biorefineries a sound knowledge is required in land availability, biomass availability, biodiversity in crop production, maintenance of high soil fertility maintenance of high crop yields, population growth and demand, type of animal production (sheep, chicken, pigs, beef, etc.), type and amount of any waste accumulation from the production unit, human and animal population.

Natural Biorefineries at the Rural and Village Levels

In nature, natural biorefineries occur which are of significance at the rural and village levels. Examples of these are:

* *Mushroom production*

Mushrooms rich in vitamins and with a dry basis 20-35 per cent protein content bioconvert through extracellular enzymes, complex lignocellulosic materials and other inedible organic residues and wastes that have little or no market value into building and soil-binding materials. The productions of edible mushrooms make an important contribution to the nutrition and economic welfare of rural populations that have little access to meat-protein. A fast-growing rural and village income-generating venture that facilitates conservation of environmental aesthetics, the age-old medicinal value of mushrooms has given rise to a new development, i.e. the production of nutriceuticals.

* Composting

Composting is the controlled microbial bio-oxidation process involving biodegradable organic matter, conducted under *controlled* environmental conditions. A *controlled* process offers a self-sanitizing mechanism by which pathogens, seeds and heat-labile microbial and plant toxins are destroyed, and, which distinguishes composting from the putrefaction of organic matter. The final humus-like material the compost, is a dark, crumbly, earthy material which has good soil structuring characteristics. The related process of *vermi—composting,* i.e. composting with earthworms in conjunction with aerobic micro-organisms to bring about the subsequent stabilisation of biodegradable organic matter, requires the addition of anaerobic digester sludge.

* Silage fermentations

Silage is forage, crop residues or agricultural and industrial by-products preserved by acids, either added or produced by natural fermentation. Silage making is practiced widely in intensive animal production systems in a temperate region, such as Europe, to bridge periods of the year when there is no high quality feed available in the fields and to supplement feed to improve milk production in the dairy industry.

In summary, bioenergy production, composting, silaging and mushroom production ensures that lignocellulosic biomass is fully exploited rather than be discarded as waste. *De facto,* the natural small-scale biorefineries as devised by nature are bio-refineries that have been so enzymatically designed to establish a multi-product system that is evidenced in the availability of a number of commodity and utility by-products.

* Bio-integrated systems of waste management and environmental conservation

Anaerobic digestion as an integrated component of environmental biotechnology involves the use of mixed microbial populations in rural communities for the recycling of human, animal and vegetable wastes and effluent treatment providing in many cases valuable fertilisers and/or biofuel cooking gas. Mainly through empirical means a variety of biological treatment systems have been developed that range from cesspits, septic tanks and sewage farms to gravel beds, percolating filters and activated sludge processes coupled with anaerobic digestion for the sole purposes of counteracting health hazards, conserving the environment, and providing opportunities in the rural labour markets.

It also enhances gender equality, the institutionalisation of clean and green income-generating activities, and contributes towards improvement of the quality of life in the rural communities.

A number of bio-integrated systems have been established in developing countries. The most impressive installations of methane producing fermenters can be found in the Peoples Republic of China and the Philippines. Digesters up to 400 m^3 in a series of 5-6 are a common sight on the outskirts of Shanghai or in rural areas. It is in the rural areas where there exist some 4 million family size plants in China today.[17]

The Maya Farm on the outskirts of Manila in the Philippines and biogas plants in Sweden are typical examples of the utilisation of methane produced from animal waste for electricity, power, and heat generation.

The Maya Farm covered 36 hectares, contained 25,000 pigs, 70 cattle and 10,000 ducks, and comprised of three integrated farming systems, varying in size from a small family farm model to a large commercial feedlot venture

- The family farm is based on 1.2 ha of land with 1.0 ha used for crops (rice or corn) and the rest devoted to a cattle shed, fishpond, biogas works, accommodation and a pigsty containing four sows. The biogas, produced from the swine waste and manure from two water buffalo, is more than enough to supply the family's energy requirements for cooking, and also powers a refrigerator and gas mantle lamp.
- The medium scale system is based on 12 ha of land and a 48 sow piggery. The gas is sufficient to pump water for the farmhouse and livestock and to irrigate the 12 ha of cropland. The large system was designed for 500 sow units and no agricultural land, approximating an intensive animal feedlot. The gas produced is used for pumping water, lighting the pigpens and operating a feed mill; however, in this case there is a gas surplus amounting to roughly 40 per cent of the output. Payback periods varied from 18 to 39 months (for the family farm system).

In China, the best example is that of the Xinbu Brigade which started to install biogas units in 1976, and where 80 per cent of the families use biogas. These units supply some 50 per cent of the families' fuel requirements, and in addition, 17 families use solar roof panels which, with biogas, supply 70 – 80 per cent of their energy needs. The biogas is used for cooking and generating electricity for lighting, and the waste heat from the engine is used to dry silkworm cocoons. The slurry is used to feed fish ponds and fertilize the fields growing mulberry, sugar cane and Napier grass. In addition, some of the slurry is used to grow mushrooms. In the six years that the scheme has been in operation, the output from the Brigade (in Yuan) has risen by 150 per cent and the general sanitary conditions of the village have improved considerably.

"The integrated approach has to evaluate energy as a means to produce more food for the world and to consider food as metabolic energy. It is not surprising that in Nature these two aspects are connected, and this lead. The way to a similar consideration by rural planners. The combination of producing food and energy simultaneously, using the by-products of one as substrate, or complementary to the other, is the right path to be take"

Ethical and Environmental Concerns

Three decades ago ethical concerns were raised as to whether arable land and forests should be used or cleared to produce bioethanol - a biofuel that was to aid primarily the automobile industry and in general the transportation sector; *En bref,* it was the dilemma of investing either in food production or fuel generation, in short *Food versus Fuel* or the inability of the poor worldwide to physically and financially access food, and, on the other hand the need to use cheaper and cleaner fuels in response to the then fossil-fuel price hikes and environmental crisis.

In current times, especially in the context of the "gold rush" to tap biorenewable resources for the production of bio-diesel, the clearance of vegetation and forest land for establishment of large-scale biorefineries using palm oil feedstocks[18] in Southeast Asia[19] has led to concern expressed by the non-governmental community especially in Europe that there are ethical and environmental issues that need to be addressed.[20] Such palm oil feedstocks produced in this manner have been termed as *"deforestation diesel".*

Poverty Restriction

The Johannesburg Declaration draws attention to the 'ever-increasing gap between the developed and the developing countries that poses a threat to global prosperity, security and stability' and emphasizes efforts aimed at eradicating poverty which erodes health, leads to hunger and starvation and the onset of preventable communicable and contagious diseases (Box 2).

Box 2: Hunger

Drought, hunger natural disasters, armed conflicts, poverty, malnutrition contribute to hunger in more than 20 countries. For example, in Afghanistan, Angola, Sudan, and Tajikistan:

- 830 million people suffer, worldwide, from malnutrition and hunger;
- About 33,000 people starve to death everyday;
- 800 million, at least, suffer from malnutrition;
- 790 million live in developing countries, often, home of the poor and hungry;
- 200 million are children under 5 years of age;
- 100 million go hungry due to drought;
- 180 million (sub-Saharan Africa), 525 million (Asia), and 53 million (in Latin America) subsist on 1,800 calories per day or less. Only in rare cases is hunger due to actual shortfalls of food. As a rule it is a direct consequence of dire poverty.

Sources: Novartis, Union of Concerned Scientists, World Food Programme.

The Plan of Implementation (PIM) of the World Summit on Sustainable Development acknowledges that biodiversity plays an integral role in sustainable development and poverty eradication and recognizes the Convention on Plant Biodiversity as an effective instrument to combat the loss of biodiversity. The PIM also calls for 'practical measures' for access to the results and benefits arising from biotechnology based on genetic resources' (Box 3).

Central Asia and Mongolia[21] have unique genetic resources, traditional knowledge concerning endemic medicinal plants and geographical and climatic conditions. However, these natural assets and dwindling petroresources and fossil-fuel bases economies are threatened by the modernizing forces of globalisation accelerating the erosion of Mother Nature's endowment of plant medicinal biodiversity.

Mining, hydro-electric power projects, high-tech agriculture and the biopiracy of traditional knowledge erode once-thriving economies that now are stricken with poverty health-deteriorating symptoms.

Given the inexorable impact and severity of the phenomenon of globalisation, capacity development programmes have been initiated. The focus of these programmes is on the following: biodiversity conservation; the promotion, protection, and safekeeping of traditional

Box 3: Global Status of Commercialized Biotechnology based on GMO

& Global status of Commercialized Biotech crops

- **Milestones reached in 2006 in an total of 22 countries comprised of:**
- 6 industrialized countries in the European Union (EU) ! the Czech Republic, France, Germany, Portugal, Slovakia and Spain;
- 4 non EU countries ! Australia, Canada, Romania and the USA;
- 12 developing countries ! Argentina, Brazil, China, Colombia, India, Iran, Honduras, Mexico, Paraguay, Philippines, South Africa and Uruguay.
- Approximately 10.3 million in 22 countries planted 102 million hectares of biotech crops.
- More than half [55 per cent or 3.6 billion people] of the global population of 6.5 billion live in the 22 countries where biotech crops were grown and generated significant and multiple benefits.
- The six principal adopters of biotech crops in order of planting were the USA, Argentina, Brazil, Canada, India and China.
- The global biotech area of the commercialisation of biotech crops during the period 1996-2006 was 577 million hectares or 1.4 billion acres equivalent to the more than half of the total land area of the USA or China, or 25 times the total land area of the UK.
- For the decade 1996-2005 the global accumulated impact of biotech crops in terms of net economic benefits to biotech crop farmers was US$ 27 billion [$13 million for developing countries and $14 million for industrial countries].

Source: James, C. (2007). Global Status of Commercialized Biotech/GM Crop 2006, ISAAA Brief No. 35-2006, *Crop Biotech* Special Edition, January 18, 2007.

knowledge which helps to ensure the rational use of renewable bioresources for biofuel production as well as for initiating professional education and public awareness in rural and sustainable development (Table 3).

The Asian Club of Emergent and Rising Biobased Economies

The club of the emergent and rising biobased economies is widespread and includes Brazil in South America, South Africa in Africa to clusters in Asia (Box 4). These countries invest in *white* and *green gold* in comparison with the Middle Eastern region that has a vast natural but finite resource of fossil-fuel rich *black gold.* In the greening of their energy requirements in the transportation sector, China and India have initiated policy initiatives that emphasize the use of biofuels to reduce

Table 3: Some Capacity-Building Initiatives on Biorefinery Issues in Asia

Year	Country	Activity	Remarks
Biocommercialisation			
2006	Singapore	Commercialisation of Biotechnology Crops in Asia	Theme: *Moving from ideas to useful products in farmers' fields*; Sponsor(s):Asia Biobusiness Pte Ltd., the National Institute of Education and ISAAA[22]
Biogas			
2000	Turkmenistan	Conservation ofhuman health	A Turkmenistan 2000 Demographic and Health Survey by the Ministry of Health and Medical Industry, Ashgabad, found that virtually all rural households use biogas to meet their energy, cooking and heating needs.
2002	Kyrgystan	Hybrid of 4 biogas units and a micro hydro plant has been established in the Kizil-Charba village in the Talas region.	Power supplied to 22 households by the biogas units which are heated in the winter by electricity from the micro hydro plant and which 4 gas units yield fertiliser as by-product.
2003		UNDP with local NGO introduces bio-gas plant in Nurmanbet village in the Issyk-Kul region.	The aim is to provide local people with alternative and autonomous sources of cheaper, clean and non-polluting energy.
2004	Kazakhstan	Creation of an Education Biogas Centre.	The biogas centre known as *Azure Flame* is located in Karaganda for Purpose of introducing biogas technology and allied process benefits is to improve the economical, environmental and social situation of rural communities.

Table 3 continued

Table 3 continued

Year	Country	Activity	Remarks
	Mongolia	Development of a biogas plant by a local enterprise -the Inner Mongolia Huaqi Biotechnology Co. in cooperation the with the Experimental Animal Research Centre of the Inner Mongolia University and Inner Mongolia Livestock Improvement Centre as a showcase model highlighting a sustainable system of agriculture that uses high-efficiency, low-pollution technologies that are replicable elsewhere in the rural areas of Mongolia	Based on a breeding base of several million dairy cows in theLiangcheng County in the zone that includes: Hohhot - the capital city of the Inner Mongolian Autonomous Region; Jining - in the middle-western part of Inner Mongolia is the administrative centre of Ulaan Chab, and Datong in the Shanxi Province of China, 400 km northwest of Beijing, in attempt to control the spread of diseases; enhance rural electrification and enhance income-generating activities such as marketing of digester residue as soil conditioners and biofertilsers
2005	Uzbekistan	UNDP with the Ministry of Economy, and authorities of the Tashkent Province , and an NGO of local farmers established a pilot biogas plant in Zangi-Ata Rural District.	The attempt of a 4-year duration is to demonstrate to local farmers the efficiency of using biogas as a clean low-cost biofuel which is accompanied by several ancillary benefits and income-generating activities that can provide an impetus to some 9340 farms that have cattle, sheep, pigs and chicken, to adopt this environment-friendly technology.
2006	Tajikistan	UNDP Tajikistan is promoting the use of biogas production in Sharak, a village in the district of Muminabad that has 13,000 inhabitants who derive their energy needs from the use of Tapak cakes [i.e. cattle dung mixed with straw and water and then dried] which emits toxic and non-environmental friendly fumes injurious to human heath and the environment.	The aim of introducing biogas technology and allied process benefits is to improve the economical, environmental and social situation of rural communities.

Table 3 continued

Table 3 continued

Year	Country	Activity	Remarks
Bioremediation			
2005	China	Bioremediation of Contaminants in the Water and Soil Environment.	Sponsors: Sun Yat-sen University; INRA[23] French Ministry of Foreign Affairs and Guangdong Provincial Department of Science and Technology.
2006	Malaysia	Remediation and Management of Contaminated Land: Focus on Asia.	Sponsors: Petroleum Nasional Berhad, Department of Environment Malaysia, The Institution Engineers Singapore *et al.*
	Thailand	Bioremediation and Wastewater Treatment.	King Mongkut's University of Technology.
Biosafety			
2004	Sri Lanka	Biosafety in Asia: Setting a research agenda for the conservation of natural resources.	Sponsors: International Development Research Centre (IDRC) and International Union for the Conservation of Nature and Natural Resources.[24]
	India	Economic Considerations of Biosafety and Biotechnology Regulations in India: A Policy Dialogue.	Sponsors: IFPRI[25] and RIS.

dependence on the use of fossil-fuel. In fact, China and India, now widely acknowledged as the new emerging superpowers on the international scene [and often described as the *Chindia*[26] phenomenon], along with the ASEAN community of Member States and the Asian component of the APEC entity, constitute the new power base of the geography of the biosciences and biotechnologies.

Box 4:Asian-Pacific Geoeconomic and Geopolitical Strategic Ventures

- Fifteen per cent of the total consumption of transport fuels in China will be replaced by biofuels by 2020.
- China promotes South-South cooperation with establishment of ethanol plants in Philippines and Nigeria.
- China engages in biofuel research and production with Madagascar, Malaysia, Mauritius, and isle de Réunion.
- With *Jatropha curcas,* India embarks on the greening of deserts and wastelands.
- Transcontinental South-South cooperation established within framework of the India-Brazil-South Africa (IBSA) Summit.
- Development of an export market of Indian *'Maruti'* cars within the framework of South-South *green mobility* in Angola, Benin, Chile, Costa Rica, Djibouti, El Salvador, Ethiopia, Guatemala, Morocco, Sri Lanka, and Uganda.
- ASEAN[27] Energy Ministers call for harmonisation of standards for biofuels and cooperation in use of renewable energy to counteract the negative impact of soaring fossil-fuel prices on 'one of the world's most dynamic regions'.
- APEC[28] creates a Biofuel Task Force to study and implement bioenergy products across Asia.
- Malaysia, Indonesia and like-minded nations engaged in palm oil production are proposing the creation of an OPEC-style cartel "to regulate international prices [of palm oil], fight tariff barriers in developed countries, and promote palm oil as a feedstock".

***Sources*:** See BIOPACT 2006 and Asia News.[29]

The club of the emergent and rising biobased economies in the developing world constitutes the third wave of globalisation that follows from the first wave when these countries were dominated by a period of discover, colonisation, and exploitation of natural resources and historical treasures; and from the second wave that was characterized by licensed development via the implantation of the multinational corporations.

Conclusion

Countries in the Asia-Pacific region[30] are dependent upon imports of fossil-fuel diesel to maintain and sustain the current advances made in the economic and technological sectors. Simultaneously they are faced with the need to reduce air pollution and greenhouse gas emissions as well as reduce their dependence on imported fossil fuels.

In this situation of contradictions and paradoxes several of these countries are turning to a series of bioconversion processes that are encompassed by the biorefinery concept, and emphasise investment in and the utilisation of a variety of biorenewable low-cost feedstocks such as the Jatropha plant[31] and palm oil. Such a strategy helps boost export earnings coming from making available locally produced biodiesel at prices that are welcomed by the EU and other industrialized societies that are faced with the unreliability of available oil supplies particularly in the context of harsh winters and of rising oil prices as was the case in 2006.

In summary, resort to the use of biorefineries has a human dimension in opening up novel and cheaper vistas for the production of food and utilisation of agricultural products with greater efficiency and in larger quantities in environmental management, sustainability of economic progress, poverty eradication and health improvement in developing countries. Biotechnologies for environmental improvement (sanitation, clean water, and bioremediation) and genetically modified crops help increase biodiesel feedstock availability and quantity and the authenticity of genetic resources in developing countries.

It can only be hoped that the presently existing industrial concept of one source to one product plus multiple wastes will be converted into a more sustainable biorefinery concept of one source to a series of products without waste in the very near future. Such a change would not only benefit Mother Nature, but also contribute to the reduction of poverty and starvation apart from making living on this planet easier.

Endnotes

[1] Rhus is a genus approximately 250 species of woody shrubs and small trees in the family Anacardiaceae. They are commonly call sumac or sumach. The name derives from the Greek name for sumac, rhous.

[2] Ford Predicts Fuel from Vegetation,» New York Times, Sept. 20, 1925, p. 24..

[3] http://catfish.colorado.edu/~gregorys/BiodieselEmissions2.html

[4] "Energy Independence is the lifeline of a nation"—Dr. A. P. J. Abdul Kalam, President of India, 2006.

[5] IEA Bioenergy (2003).

[6] Doelle (1982) and Doelle (1986).

[7] Currently, Tamil Nadu is the only state to have a formal Bio-Diesel Policy to distribute wasteland to the poor farmers for the growing of Jatropha crops.

[8] Doelle et al. (2000).

[9] Doelle & Doelle (1989).

[10] DaSilva (2001).

[11] Enebish (2005).

[12] Bui et al. (1997).

[13] AFDC 2000; Schöpe 1996; Freidrich 2004; van Gerpen et al. (2004).

[14] DaSilva (2001).

[15] Doelle et al. (1993a).

[16] Doelle (2001).

[17] FAO (1992).

[18] Prateepchaikul and Apichato (2003).

[19] Asia Pacific Biodiesel Market Likely to Display Significant Growth—http://www.marketresearch.com/map/prod/1374508.html

[20] Scientist are taking 2nd look at biofuels —Rosenthal, E. In: International Herald Tribune,, Wednesday, January, 2007, Paris Edition, Paris_ France

[21] Enebish (2005).

[22] International Service for the Acquisition of Agribiotech Applications.

[23] Institut National de la Recherche Agronomique

[24] The International Union for the Conservation of Nature and Natural Resources [IUCN]. Use of the name "World Conservation Union" began in 1990. The full name and the acronym are often used together since users still know the Union as IUCN.

[25] International Food policy Research Institute; and, Research and Information for Developing Countries.

[26] Chindia is a newly coined word that refers to China and India together in general and their economies in particular. The credit of coining the now popular term goes to leading Indian economist and politician Jairam Ramesh. China and India are geographically proximate, and are as emerging superpowers that are amongst the fastest growing economies in the world. Together, they account for one-third of the human population, have been named as countries with the highest potential for growth in the next 50 years in the Goldman Sachs BRIC report.

[27] Association of South East Asian Nations.

[28] Asia-Pacific Economic Co-operation.

[29] BiofuelsMarketplace. com

[30] Raju (2006).

[31] Euler and Gorriz (2004).

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www.ris.org.in/abdr.html

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From Petro to Agro: Seeds of a New Economy

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Abstract: The world's economy is beginning to shift from one primarily dependent upon petroleum as its foundation, to a new biologically-based economy. The basic unit of commerce is changing from the hydrocarbon molecule to the gene. This shift from a petroleum-based economy fraught with environmental problems, to a more environmentally benign biobased economy enhances the significance of agriculture as the source of not only food, feed and fibre, but also of energy, materials and chemicals.

Keywords: Biobased; biorefineries; biotechnology; agriculture; GMOs.

Introduction

As the biobased economy continues to expand, nations need to consider their position in the new economic order and begin to plan their future role now. Differing diplomatic challenges and viewpoints within the framework of the UN Convention on Biological Diversity and transatlantic approaches to the labeling and use of genetically modified crops exist.

Nevertheless, new international relationships will be based upon the increasing interaction and interconnectivity between the gene-rich/technology-poor countries of the developing world [the source of raw renewable materials for global bioeconomic development] and the gene-poor/technology-rich countries of the developed world.

Agriculture, the new foundation stone of the bioindustrial, energy, and heath sectors, offers the most economical and environmentally friendly methods to produce large quantities of biorenewable biomaterials.

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The Age of Geology

For much of the last century, and particularly since the end of World War II, petroleum has been the primary raw material for the world's economy. In 2004—the last year for which data are available—crude oil and NGPL (natural gas plant liquids which are hydrocarbon liquids obtained when extracting natural gas that are combined with petroleum) accounted for 38 per cent of the world's energy supply. Coal stood at 26 per cent, while natural gas accounted for 23 per cent. Hydropower and nuclear power each accounted for 6 per cent, and a variety of other sources combined accounted for just 1 per cent.[1]

The US consumption of petroleum is typical of worldwide trends. The bulk of US petroleum use goes to meet energy demands, with approximately 90 per cent of a barrel of crude oil going to gasoline, diesel, and other fuels. Since 1949, however, the industrial consumption of petroleum for nonfuel use in the US has increased nearly sevenfold.[2] The chemical industry, for example, relies on petroleum for more than 90 per cent of its raw materials to manufacture its myriad of products, ranging from plastics, refrigerants and fertilizers to detergents, explosives, and medicines. Virtually everything requires petroleum or petroleum derivatives for its manufacture.

As the twentieth century was ending, Michael Bowlin, then the president of the American Petroleum Institute, and chief executive officer of Arco, told industry executives that the world was entering *"the last days of the Age of Oil"*.[3]

Estimates of the remaining life of the reserves vary widely, but many experts agree that worldwide oil production will peak between 2010 and 2020. Even if there is agreement with those who hold that the petroleum supply may be renewable, environmental pressures and economic incentives will remain that will move us to newer technologies. Far from repeating the apocalyptic warnings of the 1960s and 1970s about the end of oil, however, there is no doubt that the new technologies will replace petroleum.

The Age of Biology

Prominent among the replacements for petroleum are products developed from biological sources. Using biomaterials obtained from plants and animals as raw materials for industrial and consumer products is not new. Before the rise of cheap oil, agriculture was the dominant source of raw materials. Indeed, when the US Department of Agriculture was established in 1862, its motto proclaimed, *"Agriculture is the Foundation of Manufacture and Commerce."*

Even today, agriculture supplies raw materials for industry; for example, as recently as 2002, about 8 per cent of the US corn crop went to industrial uses rather than directly towards meeting food or feed requirements.[4] Some US government estimates suggest that if current trends continue, within the next five years, nearly one-third of the US corn crop will be used solely for ethanol production. While that seems unlikely, as alternative feedstocks will no doubt be developed, it still illustrates the growing demand for industrial uses of crops. Agriculture offers the most cost-effective way to manufacture large volumes of biologically based raw materials.

In its vision statement for the twenty first century, the National Agricultural Biotechnology Council—a consortium of leading agricultural research universities in the United States—forecasts agriculture to be the source of not only our food, feed, and fibre, but also our energy, materials, and chemicals.[5] In a 1999 report on biobased industrial products, the National Research Council noted that US farmers already generate annually about 280 million tons of waste biomass—leaves, stalks, and partially used plant portions. That is more than sufficient material to serve as feedstock for all of the domestic industrial chemicals that can be readily manufactured from agricultural sources.[6]

One argument that is often posed against the move to a biobased economy relying on agricultural production is that it will take land and crops away from food and feed production. In the United States, for example, resources needed for food and feed production will not compete with resources required to grow industrial raw materials. The United States has the largest arable land per capita of any country in the world (1.73 acres for the United States versus 0.99 for other developed countries; the developing world average is only 0.49 acres).[7] Additionally, through the US Department of Agriculture's Conservation Reserve Programme, 35 million acres are left fallow each year, some of which could be used to grow crops specifically for biomass. Even in those countries with less available arable land, the use of intensive agricultural techniques could provide adequate yields and biomass to sustain both food/feed and industrial demands.

Water does present some local and regional challenges to the potential expansion of agriculture. As the need for affordable water increases, however, improvements in irrigation technology and the development of new water resources are likely to follow. One estimate suggests that improvements in irrigation technology alone can reduce the anticipated worldwide demand for additional water resources by one-half during the next 25 years.[8] Thus, concern about water availability is not likely to present a barrier to expanded agricultural production.

Technological innovations in agricultural production undoubtedly will continue to increase yields. Corn yields in the US, for example, gained an average of 1.0 bushel per acre per year during the last century. In the last half of the century, the average increase was 1.8 bushels per acre per year. Depending on soil characteristics and water availability, even something as simple as the spacing between corn rows can be used to maximize yields. Corn yields in the United States averaged 138 bushels per acre for the decade of 1996–2005, vs. 115 bushels per acre for the previous decade. Some researchers believe that within the next 20 years technology and cultural practices can increase yield averages to nearly 260 bushels per acre.[9]

While the production capacity to produce and process the raw materials for a biobased economy are available, for most current industrial practices, the cost of the conversion process—turning biomass into energy, materials, and chemicals—is not competitive with petroleum. Of course, making such cost comparisons varies, based in large measure on the price of oil. However, even with the recent rise in oil prices, it is still fair to say that petroleum-based products are generally less expensive than biobased products.

One key problem with making cost comparisons is that the production costs are based on existing facilities designed for petroleum feedstocks. When using biomass, some of the end products can be made through direct physical or chemical processing; others can be produced indirectly through fermentation (using microbial agents) or by enzymatic processing. What is needed is "biorefineries".[10] Like an oil refinery, a biorefinery would take carbon and hydrogen and produce desired products. The biorefinery's economic advantage will emerge from its dual capability. Along with the desired end products, foods, feeds, and biochemicals could be produced.

Prototypes of the biorefinery already exist in our industrial base in the form of corn wet mills, soybean processing facilities, and pulp and paper mills. While the prototypes of full-scale biorefineries are mostly in the planning stage at the moment, two facilities designed for specific biobased end products have been operating in the United States for the past few years.

One of the largest biomaterials facilities in the world has been built in the US state of Tennessee and is operated under a joint venture between DuPont and Tate & Lyle BioProducts.[11] In mid-2001, DuPont announced that it had successfully manufactured a key ingredient in a new clothing polymer (now known as Sorona™) from corn sugars instead of petrochemicals—previously the only source for the polymer.

The biobased version of the key polymer used in Sorona™ —1, 3 propanediol, or PDO—is marketed as Bio-PDO™ . At the end of November 2006, DuPont announced the first commercial shipments of Bio-PDO™ from the $100 million Tennessee plant. Products incorporating Sorona™ are expected to be available by early 2008 and used in a wide variety of applications, including cosmetics, liquid detergents and anti-freeze.

For the last four years, NatureWorks, LLC—a wholly owned subsidiary of Cargill—has been manufacturing a biodegradable plastic made from sugars derived from cornstarch. (The manufacturing takes place in a $300 million plant in the US state of Nebraska, specifically built for the production of biobased products.) The plastic—known as PLA, or polylactide acid—has already been incorporated into products for large food sellers, including Coca-Cola and McDonalds. The corn-based PLA can be incorporated into a number of products that replace current petroleum-based polyesters, polyolefins, polystyrenes and cellulosics; for example, fibres, non-wovens, films, extruded and thermoformed containers and emulsion coatings.

NatureWorks is also currently manufacturing the world's first artificial fibre, named Ingeo™ , completely constructed from renewable resources. The fibre is stain-resistant and is being used for many items ranging from pillows to carpeting to padded outerwear. A most interesting recent application of Ingeo™ was revealed at the first European Bioplastics conference, held in Brussels in November, 2006: a biopolymer-based wedding dress created by a famous fashion designer and sponsored by a major European agricultural organization![12]

The biobased economy is growing at a rapid pace and is much more than just two biorefineries. A simple Internet search of the words "biobased plastics" yielded nearly a quarter of a million entries, for example. Many new partnerships are being forged.

One good illustration is the partnership announced between DuPont and British Petroleum (BP) to manufacture biofuels. By the end of 2007 they anticipate marketing biobutanol made from agricultural materials. Many new products are being introduced to the marketplace. BiOH™, for example, is a new biobased foam product introduced by Cargill that is a replacement for previously petroleum-based foam and has gained wide acceptance in the furniture industry.

In November 2001, the Organization for Economic Cooperation and Development (OECD) published *The Application of Biotechnology to Industrial Sustainability*—one of the first studies to demonstrate the ecological and economic advantages of using biotechnology, biobased feedstocks and bioprocesses on an industrial scale. The European Union is also investing in the biobased future and examining the role of biorefineries. The EU has established EPOBIO, which is an international effort with the objective "to design new generations of bio-based products derived from plant raw materials that will reach the market place 10-15 years from now". The initial areas of study are plant cell walls, plant oils and biopolymers. In May 2005, EPOBIO held a workshop specifically focused on the future of biorefineries.[13]

Similarly, Canada is also preparing for the biobased future with the formulation of the Strategic Plan for the Canadian Biomass Innovation Network (CBIN) that will serve as a guide, specifically "to improve the availability of biomass feedstocks for energy and industrial uses, and develop technologies, processes and systems that convert biomass into energy, biofuels, materials, chemicals and other industrial bioproducts".

Biobased materials will only be successful if they are competitively priced with their petroleum counterparts. As much as individuals and corporations like to talk about being 'green', experience has demonstrated that they are seldom prepared to pay any sort of premium price. With the recent increases in world oil prices, the biobased materials have gained some advantage. However, oil prices are volatile, and can just as easily fall again. The important point is that the first steps have been taken to construct true biorefineries. Just as petroleum refineries have improved their efficiencies and profit margins over the last century, biorefineries will do likewise. Moreover, as we learn to derive sugars from the cellulose in the plant matter—as opposed to the starch in the grain—the base of source materials will significantly increase (e.g., we could use agricultural waste, or biomass) and the costs will decline.

Is this biobased economy just a vision with a few immediate examples, or is there a long-term probability for its success? In its 1999 report on biobased industrial products, the National Research Council—an agency of the United States' National Academies—argued that a competitively priced, biobased products industry eventually would replace much of the petrochemical industry. As an intermediate goal, the report suggested that by 2020, a biobased economy could provide 25 per cent of the 1994 levels of the United States' organic carbon-based industrial feedstock chemicals and 10 per cent of liquid fuels. The report suggested that, ultimately, 90 per cent of the US organic chemical consumption and 50 per cent of our liquid fuel needs could be met by a domestic biobased economy.

In this new economy, plants and animals will be specifically bred and farmed to produce desired raw materials. For example, if an industrial process requires a chemical to have certain tolerances to heat, a protein may be available to provide that tolerance. The protein, which would be the product of a gene, could be derived from plants. If the protein occurs naturally in animals or in plant species that are not easily farmed, genetic engineering offers the ability to transfer the gene to a plant species more suited to agricultural production. Once introduced into an agriculturally desirable plant, the protein can then be produced more cost-effectively and made available on a commercial scale.

Fueling the Biobased Economy

As the biobased economy matures and issues of production and processing are improved, the demand for new products will grow. New products will require new raw materials. In a biobased economy, the basic raw material will be genes, and novel genes will be the source of novel products. Thus, as we shift from an economy based on geology to one based on biology, the basic unit of commerce will shift from the hydrocarbon molecule to the gene. Just as we currently demand assured access to sources of hydrocarbons, in the near future we will demand assured access to a broad-based, diverse supply of genes.

As with any resource vital to our economy, the location of large supplies of genes will become important to a country's national security concerns. In our petroleum-based world, the resource is concentrated in various pockets distributed worldwide in nearly all climate regions. Obviously, genes are distributed worldwide, as there is life in every nook and cranny of this planet. However, the overwhelming majority of genes are concentrated in the equatorial regions.

Biologists refer to a region's biodiversity when commenting on the range of life forms present. The more life forms present (that is, the more genes present), the greater the biodiversity. The general biological principle of the latitudinal diversity gradient contends the closer to the equator, the greater the biodiversity. The amount of solar energy present, the lack of seasonal climate fluctuations and the expanse of land explain the gradient's existence. By way of illustration, consider the results of a study that used comparable sized plots of land at different latitudes to compare the number of different bird species found at each latitude: Greenland, 56 species; New York state, 1[illegible]5 species; Colombia, 1,525 species. Plants show a similar degree of biodiversity. For example, in all of Canada and the United States, there are only 700 native tree species. In one census involving about 25 acres in Borneo, more than 1,000 different tree species were cataloged.[14]

International Implications

In a biobased world, international relations with Ecuador (to use a representative country that takes its very name from the equator) will be more important than those with Saudi Arabia. At this early stage in the biobased economy, it would be wise to consider what controversies could arise over another nation's genetic treasure and how best to secure access and provide compensation to the regional owners. These are not new issues.

A classic example that illustrates the potential issues is the rosy periwinkle plant of Madagascar. In the early 19[illegible]0s, a plant biologist working for the US drug firm Eli Lilly extracted two cancer-fighting compounds from the flower. During the course of the patents on the two compounds, Lilly earned hundreds of millions of dollars from the sale of the drugs. Madagascar received no compensation whatsoever.

By the early 1990s, two documents were ready for international agreement that sought to address cases like that of the periwinkle, among other things. The Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement—part of the Final Act of the Uruguay Round of Multilateral Trade Negotiations—sought to strengthen international intellectual property protection in order to promote world trade. The United Nations Framework Convention on Biological Diversity, known commonly as the Biodiversity Treaty, sought to preserve agrarian societies and promote sustainable development.

Emblematic of the problems associated with intellectual property rights were the 1993 riots in India directed against W.R. Grace, a US chemical firm. Indian farmers were protesting that Grace had a patent on an insecticide derived from the neem tree, even though the farmers had a traditional method to extract the compound from the leaves. Although Grace's process gave the compound a shelf life and allowed it to be transported to areas where neem trees were not available, the farmers accused Grace of 'gene piracy'.

The Biodiversity Treaty sought to address the issue of the biodiverse-rich underdeveloped countries seeking compensation for the resources taken and used by the technology-rich developed countries. Provisions of the treaty require biodiverse-rich countries to provide access to genetic material in return for the developing countries providing a fair and equitable share of the benefits. US pharmaceutical and biotechnology firms initially opposed the treaty. Eventually, however, they dropped their opposition, out of fear that it might ultimately preclude their exploration for genetic resources in underdeveloped countries. The treaty was signed by President William Clinton in 1993, but was never ratified by the US Senate.

Although the treaty was not ratified by the United States—meaning it is not a party to the treaty—the business sector moved forward with an agreement that serves as a model for such arrangements. In 1991, Merck and Company signed an agreement with the Costa Rican Institutio Nacional de Biodiversidad (INBio) for a 2-year renewable contract, in which INBio supplied Merck with extracts from plants, insects, and microorganisms for its drug-screening programme. In exchange, Merck paid INBio $1,135,000 and royalties on any resulting commercial products.

Thus, even more than a decade ago, the business sector was quite aware of the potential for genes as raw materials. This is especially true in the pharmaceutical industry at the moment, as about one-fourth of all prescription drugs contain an active ingredient derived from plants.

In a biobased economy, with many players seeking access to the biodiversity treasures of developing countries, the possible international scenarios that might arise are limitless: conflicts between developed countries over who had access to what gene at what time; conflicts between developing and developed countries over access to genes and compensation; conflicts between developing countries over territory, and thus ownership, of particular stores of genes.

In this context, a serious dilemma could surface if a state set out to destroy large amounts of diverse genetic material. This is not a hypothetical situation. It is estimated that some 31 million hectares of rainforest are destroyed annually. Article 3 of the Biodiversity Treaty states that countries have the *"sovereign right to exploit their own resources pursuant to their own environmental policies."* If genes were the basic unit of commerce, would the international community tolerate another state's environmental policies that allowed for the continued destruction of the rainforest?

Another likely point of international friction will be the use of transgenics. Moving genes from one species to another provides for tremendous diversity and the opportunity to create new products. It also raises safety and ethical concerns about introducing such genetically modified organisms (GMOs) into the environment

A distinction is drawn between GMOs that are nonliving end products that would have no effect on the environment—for example, the heat tolerance protein theorized above—and living modified organisms [LMOs], such as seeds, that may have some environmental consequences.

The use of GMOs has steadily increased since their introduction in 1996. In late 2005—the last year for which data are available—BIO, the biotechnology trade organization, reported the following:

Global biotech crop acreage grew to 222 million acres in 2005, according to the International Service for the Acquisition of Agri-biotech Applications (ISAAA). In 1996, when the first biotech crops were commercially grown, 7 million acres of biotech crops were grown worldwide. In 2004, a total of 222 million acres of biotech crops were planted in 21 countries by 8.5 million farmers. Of the 8.5 million farmers, 90 per cent are resource-poor farmers in developing countries; developing countries account for more than one-third of the global biotech crop acreage. Of the 21 countries growing biotech crops, five are in the European Union. Additionally, the one billionth cumulative acre of biotech crops was planted in 2005.

The use of GMOs will increase as the biobased economy matures, and, likewise, the potential for disputes will increase. These are not hypothetical issues for the distant future but are present day concerns. The European Union (EU), for example, had a long-time moratorium on approving the importation of GM crops. It resulted in the US, Canada and Argentina filing a complaint in 2003 with the WTO against the EU. In February 2006, the WTO ruled that the EU had indeed broken international rules. The issue is further clouded, though, by the fact that the EU has already allowed some 30 GM food and feed products to be sold in the EU, thus bolstering their likely counter-claim that the moratorium was already lifted. The point is, we are in the very early stages of the biobased economy, and we can already see protectionism and non-scientific claims being used for the preservation of national markets—things that can thwart the growth of this new industry. Environmental activists in Europe will no doubt continue to encourage EU governments to take anti-GM positions. In Australia, the Insurance Council of Australia even stated its reluctance to insure farmers, biotechnology companies, or food companies in cases involving GMOs.

Significant multilateral international efforts have been made to address specific concerns surrounding LMOs. In January 2000, the Biosafety Protocol to the Biodiversity Treaty was signed. Known as the Cartagena Protocol on Biosafety, it is the first protocol to the Biodiversity Treaty. Its intent is to provide countries the chance to obtain information about LMOs before they are imported. Moreover, it acknowledges each country's right to regulate bioengineered organisms and provides a framework to help the developing world to protect its biodiversity further. Although the United States is not a party to the Biodiversity Treaty and thus cannot be a party to the Protocol, it participated in the negotiations as a member of the so-called Miami Group, a coalition of leading agricultural exporters that included Argentina, Australia, Canada, Chile, and Uruguay.

While the various treaties and scenarios described above depict potential conflicts, not all international implications of a biobased economy will be filled with peril. For example, consider the implications for job creation. As a raw material, petroleum has considerably more energy per unit volume than biological materials. Thus, it is economical to transport petroleum from its source to distant refineries for processing and then further to ship the refinery products for use as end products or industrial intermediates. With biological materials, however, the economics will not support shipping the raw materials much farther than 250 to 300 miles from their point of origin. Biorefineries will have to be built close to the source of their raw materials. A regionalized agriculture will likely develop, with certain areas growing specific crops to supply regional biorefineries. Additional processing and manufacturing of value-added biologically based products can economically take place farther from a biorefinery but there will be limits to the distances involved. The significance is the likely creation of nonfarming jobs in rural areas.

Urbanization in the developing world is often noted as a major issue of strategic concern for the twenty first century. Currently, there are approximately 40 cities in the world with populations of 5 million or more. By 2015, it is anticipated that nearly 25 more will join the ranks. Only 11 of these 65 will be in the developed world. Moreover, the demographic structure of societies in developing countries is heavily weighted toward people 25 years of age and younger. Unemployment among large numbers of young urban males in developing countries is frequently cited as a root cause of the terrorism that we are fighting today. A biobased economy ultimately could help stem the flow of urbanization and provide rural employment opportunities.

Domestic Implications

Just as new international issues will surface as a result of our transition to a biobased economy, new domestic considerations will likewise arise. For example, in the United States, most homeland defense planning focuses on the protection of urban populations and infrastructure, while the safeguarding of agricultural areas does not receive much consideration. Agriculture simply does not enter into the thinking of most people in the developed world. Throughout most of the last century (from about 1930 to 1999), agriculture as a per cent of US employment declined nearly 90 per cent—from 23 per cent to 2.6 per cent. The number of farms declined from 6.3 million to 2.2 million. Agriculture was not even included among the eight critical national infrastructures in Presidential Decision Directive (PDD) 63, "Critical Infrastructure Protection." Interestingly, however, agriculture is included as a subgroup of the Weapons of Mass Destruction Preparedness Group resulting from PDD 62, "Combating Terrorism."

In fairness, it has not seemed particularly necessary to include agriculture as critical infrastructure, since croplands have not surfaced as likely terrorist targets. Terrorists usually aim to score immediate to near-term effects by striking high-profile targets. While a present-day attack on field crops could have a large economic price tag, it certainly would not affect our ability to feed ourselves. Food is plentiful worldwide, and the marketplace easily could meet any immediate or near-term demands. Even with the growing world population, per capita food production has actually increased during the last 30 years from 2,360 calories per day to 2,740 calories per day.

In addition to field crops, farm animals, food in the processing or distribution chain, food at wholesale or retail establishments, and agricultural facilities are all potential targets. Presently, an attack on any link in the chain would result in large economic losses, as well as likely loss of human and animal life. It is estimated that a natural outbreak of foot and mouth disease on just 10 farms would result in a $2 billion loss.[15] Losses from the 2001 outbreak of foot and mouth disease in the United Kingdom were estimated at $30 billion. However, if we relied upon agriculture to provide the raw materials for our economy, the potential disruption could be of greater magnitude.

Consider this hypothetical scenario. What if, as the National Research Council report suggests, the US did derive 50 per cent of its liquid fuels from agriculture? As new biotechnologies improve the processing of biomass, ethanol will become an economically viable option, and it will become a larger source of our liquid fuel supply. At that point, destruction of a large portion of US farmlands would be tantamount to an invasion of Kuwait.

The issue of agricultural bioterrorism is complex, but for the purpose of this argument, let us focus solely on croplands. How vulnerable are our croplands? In 1970, without planning or assistance from any organized terrorist group, a naturally occurring epiphytotic, an epidemic in the plant world, destroyed 15 per cent of the US corn crop with an estimated value of $1 billion. Although we have diversified the genetic base of corn in an effort to avoid another such disaster, crops are still vulnerable to disease. Any number of organisms, including various molds, fungi, viruses, and bacteria, can cause epiphytotics. These organisms are easily grown in laboratories, at no threat to humans, and can be transported worldwide without detection.

At present, crops present a relatively simple target set for anyone wishing to do them harm. The US crop base is fairly uniform, with 8 of every 10 acres planted to just 3 crops: corn, wheat, or soybeans. There is genetic diversity within each crop, offering some disease resistance. Predicting the actual loss for any given attack would be based on several assumptions, as epiphytotics are dependent on multiple variables.

Moisture and temperature are the most complex variables involved and are extremely difficult to predict in any long-term fashion. Nonetheless, well-coordinated simultaneous attacks in many areas, using multiple pathogens, would no doubt result in significant losses.

From a plant protection perspective, the shift to a biobased economy will have some positive aspects, though. To provide new materials for industry, there will be a demand for new genes and their products. If novel genes are found in plants that can be easily grown then their direct cultivation would be the preferred method rather than creating a transgenic with corn, wheat, or soybeans. With direct cultivation, the overall crop base would be broadened and thus provide a more challenging target set for terrorists. Also, the construction of regional biorefineries would complicate targeting more than the current groupings of petroleum refineries.

While a biobased economy will no doubt bring the developed countries the same benefits of slowing urbanization and rural revitalization as anticipated for the developing world, the net effect most likely would be marginal. These will remain predominantly urban societies. As we consider the potential terrorist threat, however, it is important to note that agriculture will assume a greater significance as a potential target.

Challenges to the Elements of Power for International Relations

Converting to a biobased economy will present new but not totally unfamiliar challenges on all fronts. This is not the first time we have developed and used new resources. Nor will it be the first time we have sought to obtain resources from other nations or wanted to trade finished products. None of these changes will happen quickly or without warning. Nonetheless, it is worth considering some possible effects on the so-called "elements of power" that nations have at their disposal when playing on the international stage. These incude the diplomatic, informational, economic and military domains.

Diplomatic and Informational Issues

Already, diplomatic challenges are being presaged by topics such as the Biodiversity Treaty and WTO complaints. Such issues may well become the norm, requiring a diplomatic corps well trained in scientific and technical skills. Water warrants some extended discussion, as it will be at the heart of diplomatic concerns in the twenty first century, regardless of the world's resource base. A biobased economy, though, may well intensify the issue.

Globally, the renewable fresh water supply has fallen by nearly two-thirds in the last 50 years. During that same period, the human population has increased nearly 250 per cent. Two-thirds of the world's water demands are for agricultural use, and while irrigated agriculture accounts for only 20 per cent of farmland, 45 per cent of the world's food supply is grown on irrigated land. By 2025, it is estimated that nearly 3 billion people—40 per cent of the projected world's population—will find it difficult or impossible to satisfy basic water needs.

The potential international points of conflict over water are also significant. Two or more countries share 261 of the world's rivers. Some 51 countries, within 17 international river basins, are at risk of water disputes during the next decade. An analysis of 1,831 international water-related disputes over the last 50 years revealed that about one-fourth resulted in violence.[16]

Although water will be a problem, it will not be an insurmountable one. In a US study published in 1999 by the National Academy of Science, it was noted that with respect to the future of water in the Middle East, additional supplies could be obtained by using a variety of techniques. Some involve improved management of watersheds and collection of water that now is lost as runoff. Other techniques use current technologies and include wastewater reclamation and desalination. Some of these can be made even more productive and economical with further improvement. Conservation still remains a significant factor in extending water supplies. Between 1985 and 1993, for example, Israel reduced its water consumption by more than 200 million cubic metres per year, almost entirely through improvements in irrigation and water delivery restrictions.

Former US Senator Paul Simon is a strong advocate of desalination. In his 1998 book on the world's coming water crisis, he noted the progress being made in desalination technologies and use. About 11,000 plants are in operation in more than 125 countries. Desalination is most widely used in the Middle East, which accounts for about 60 per cent of the world's plants. In fact, Saudi Arabia built the first modern desalination plant in the late 1930s. To be certain, the economics of desalination are still not competitive, especially for agriculture, but continued development will ultimately drive down the price. That will be especially true as the price of water from other sources rises.[17]

The informational element of the biobased economy is of particular interest and is worthy of a separate study. It is probably unprecedented that both government and business sources are being required by the general population to provide such large amounts of detailed technical information on procedures and products. This issue will only become more complicated, as non-technical societies will demand data. Additionally, bioethics considerations will have to consider differing cultural views.

Economic Issues

The economic forces of globalization at work today will not be affected by the biobased economy with the possible exception of urbanization, as previously discussed. Thomas Friedman points out that the driving force of globalization is free market capitalism.[18]

A discussion of agricultural trade may well question how much it follows the rules of a truly free market. Indeed, the recent Doha Round of WTO trade negotiations faltered, in part, over the issue of farm subsidies. Nonetheless, it is anticipated that this contentious issue will ultimately be resolved, and the agricultural sector will represent a more level playing field for those involved in the biobased economy.

Friedman also notes that globalization has its own set of defining technologies, which includes computerization, miniaturization, digitization, satellite communications, fibre optics, and the Internet. Those are the same technologies farmers in developed nations use in a technique called precision agriculture, which enables them to integrate all available data and to make the most efficient and economical decisions concerning a crop. (For example, using data collected from field sensors, a farmer may detect a developing pest problem. Rather than treating an entire field, as would have been the solution in the past, very targeted treatments can be applied, saving time and money.) While over time there may be changes to the world's economic balance of power—as new players emerge as leaders in the biobased economy—it is unlikely that any new technology will create sudden and disruptive changes to the current order.

Military Issues

Of all the instruments of national power, the military is the one most likely to be affected by a shift in the world's resource base. The instruments of diplomacy, information, and economics do not require long lead times to research, develop, and acquire the tools of their trade. Nor are the consequences potentially as serious if an initial misstep is made in exercising one of those instruments of power. The international consequences of launching military operations, however, can be long lasting and potentially fatal to those directly involved.

It can be argued that there is less likelihood of exercising the military instrument of power in a biobased economy than in our current petroleum-based economy. That may be true, especially in terms of needing to ensure a daily supply of new raw material—genes rather than oil. Nonetheless, demand for new raw material will remain considerable. Novel genes will be the source of novel products in the biobased economy. While the other instruments of power may play a greater role in securing access to novel genes, national militaries must still be prepared to operate in areas of enduring interest. An important question to ask is whether an army will have the necessary equipment to conduct a forcible entry into an equatorial region to secure the genetic resources contained in a given 5,000-square-mile patch of rainforest. The significance of the question lies in the long lead-time needed for research, development, and acquisition of weapons systems.

Despite the war on terrorism, we are at one of those periods in history in which we are not burdened by pressures of such imminent danger that our very existence is threatened. We have time to ponder the distant future. We have an opportunity to shape our relationships with those countries that will be strategically important in a biobased economy. We have an opportunity to invest in those technologies that will be important to the development of the new economy. Winston Churchill is said to have stopped predicting future events because the future was just "one damned thing after another." However, as we contemplate the future and the ultimate transition from a geologically based economy, pausing to take stock of the next damned thing—the biobased economy—may prove to be a damned smart thing.

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Bioconversion Energy Technologies: Catalysts for Bioeconomical Development in the ASEAN Region

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Abstract: Biomass energy or bio-energy in the form of forest and agricultural wastes in ASEAN is a potential substitute for the rapidly depleting fossil fuels. Recent RD/D has resulted in various efficient devices from cleaner cook stove, and kiln, the use of solid, liquid and gaseous fuels, for example, in the transportation sector which can convert biomass energy under cleaner conditions. Despite the several techno-economic merits and socio-cultural benefits offered through this environment-friendly biotechnology there are still barriers in ASEAN countries that must be overcome. Problems range from the gathering of raw materials, the use of environment-friendytechniques, code and standardisation as fuels, and disposal of harmful effluents. Biomass conversion processes also yield new biofuels such as ethanol and methanol.[1]

Keywords: Bioenergy, bioconversion technologies, ASEAN countries, CHP technology, biofuels.

Introduction

Biomass energy in the form of fuel wood or agricultural wastes, and also known as bio-energy, is the common source of energy in most ASEAN villages. The consumption of bioenergy from forest and non-forest resources in the ASEAN member countries was more than 25-40 per cent of the total national energy consumption (FAO/RWEDP[2], 1997). Vietnam in using the highest share of biomass energy sources was followed by the Philippines, Malaysia and Indonesia. The lowest use of biomass resources was reported to be in Thailand.

Biomass in most ASEAN countries is mainly used in stoves for the cooking of daily food though some may use it to produce traditional food such as *tohu,* cake and cookies, tobacco curing, red sugar and

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brick-making industries. The efficiency of the stoves, usually very low, and mostly around 5 per cent, contributes to a large portion of the energy being lost to the environment. Moreover, since the stoves do not conform to industrial standards and are low in efficiency, they emit toxic gases which could cause acute respiratory infections (ARI). With continuous population increase, access to this energy resource is becoming more difficult necessitating availability of better and more efficient stoves.

Utilization of biomass energy has other outlets such as in providing easily accessible biogas energy for cooking, the supply through CHP[3] technology of processed heat and electricity to industry and alternative biofuels for the transportation sector. In counteracting rapidly depleting fuel wood resources for cook stoves several efforts have been made to identify locally grown diverse bioresources like inedible seeds, algae, nuisance and inedible plants such as water hyacinth and *Jatropha curcas,* respectively and agro-industrial residues from the palm and coconut oil industries like ice mills, plywood mills, saw mills, and sugar mills. The quantity of these wastes alone could reach around 1.2 GWe .

As a consequence of the Kyoto Protocol with the substitution of fossil fuel coal with biomass especially the development of biobased energy generation progresses at a faster rate. ASEAN member countries—Indonesia, Malaysia, the Philippines, and Thailand having ratified the Kyoto Protocol are eligible to submit benefit from the Clean Development Mechanism (CDM). This scheme encourages the use of various biomass energy technologies to reduce global greenhouse gas emissions.

ASEAN Initiatives

Today, many ASEAN countries are beginning to use vegetable and plant oil as substitutes for the rapidly depleting fossil fuels.

Indonesia, a member of OPEC currently has become a net oil importing country. Due to the uncertainty of supply and an increasing trend of fossil fuel in the future, Indonesia, since 2005 has launched a massive national programme to produce biofuels like biodiesel and bioethanol to substitute the around a US$ 17.4 billion importation of fossil fuels. The fuel substitution plan of Indonesia envisages a conversion of 11 million tons of bioethanol from cassava and 600 million tons from molasses to produce 1.85 million kilo litres of bioethanol, 30.2 million tons palm oil, and 3.84 million tons of Jatropha oil to produce 1.24 kilo litres of biodiesel, and 4.8 million kilo litres of bio-oil in 2010.[4]

According to the *World Energy Council Report,* (2007) in Malaysia, the biodiesel *Envo Diesel* was launched in 2006. Malaysia currently produces 500,000 tons of biofuel annually and an increase in production is expected this year. *Envo Diesel* blends 5 per cent processed palm oil with 95 per cent petro-diesel whereas EU's B5 blends 5 per cent methyl ester with 95 per cent petro-diesel. Diesel engine manufacturers prefer the use of palm oil to methyl ester blends as diesel engines are designed to handle 5 per cent methyl esters meeting the EN14214 biodiesel standard, which palm oil cannot meet.

From the Philippines, coconut oil-based biodiesel is already being exported to Europe and especially to Germany. Plans are underway to export surpluses to Japan. The CME (Coconut Oil Methyl Ester) facility has an annual production of 60,000 tons which is an expansion from the original capacity of 15,000 tons.

Thailand now produces 500 k-litres/day of biodiesel from palm oil and expects to show from the expected 16000 km^2 of oil palm area in 2011 an increased yield by 2012 of 8.5 million litres/day, Thailand also produces gasohol from molasses, cassava, sorghum, rice and corn. Beside producing bio-fuel, bio-diesel and bio-ethanol for cooking, power generation and for transportation, many countries in ASEAN are also trying to make use of their respective biomass resources to generate power and heat from locally available biomass resources, namely rice husks, bagasse, other agricultural residues using CHP technology.[5]

In Vietnam, biodiesel is produced from waste cooking oil with an approximate investment of US$ 605000 by the Ho Chi Min (HCM) city's Waste Recycle Fund. A local commercial facility in HCM city district 3 invested VND 8.1 billion and it expects to recover its investment after a 3-year period.

Notwithstanding the huge biomass potential available in the ASEAN region and elsewhere in the world and the many facilitator efforts of governments and the private sector, the practical use of bioenergy is still hindered by a lack of social awareness of the merit of bioenergy resources. Other factors are the less expensive conventional CHP system; and the unavailability of the incentive (feed-in tariff, net metering) and RPS[6] schemes are not yet available on a general basis. To promote the use of renewable energy sources by incentives such as feed-in tariff and a special tariff imposed in a Distributed Small Power

Generation in Indonesia, more time is still needed for RD&D and for operational government regulations to make this competitive with subsidized power generation now existing in the ASEAN region.

Biomass and Biofuel Potential

Biomass it is now widely accepted has potential as a source of renewable energy. However its exact definition is yet to be agreed upon since biomass as fuel can have different forms, solid, liquid or gaseous fuels in relation to energy modeling such as in development planning. This is so particularly when a certain energy mix which include biomass energy become one of the probable scenarios to reduce green house gas emission. Sayigh (2003) for example, proposed the term modern biomass to differentiate bioenergy in the form of intact fuel wood with that of charcoal, which has been processed through conversion technology such using the pyrolysis process.

Biomass is defined as all organic matter except fossil fuels: that is all crop and forest materials, animal products, microbial cell mass, residues and byproducts that are renewable on a year-to-year basis.[7] This latter definition is used by the author of this contribution. Thus, for Indonesia, the targeted of >15 per cent of renewable energy share in 2025 would been surpassed this year from only the traditional fuel wood along with contributions from other renewables such as solar, wind, small hydro, geothermal and marine energy. Based on the Indonesian Presidential Instruction concerning biofuels (2006) the share of biofuel in 2025 should cover at least 5 per cent of the total national energy consumption.

Biomass consumption in rural areas of developing countries (including all types of biomass and end-uses) was about 1 ton (15 per cent moisture, 15GJ/t) per person/year and about 0.5 ton in semi-urban and urban areas.[8] The increasing interest in biomass for energy since the early 1990s is well illustrated by the large number of energy scenarios showing biomass as a potential major source of energy in the twenty first century. Hoogwijk *et al.* (2001) and Berndes et al. (2003) classified 17 such scenarios, into two categories: (i) Research Focus (RF). and (ii) Demand Driven (DD). For the period 2025-2050, the estimated potential of the RF varies from 67 EJ to 450 EJ whereas that of the DD varies from 28 EJ to 220 EJ. The share of biomass in the total final energy demand lies between 7 per cent and 27 per cent. For comparison, current use of biomass energy is about 55 EJ. Biomass will play an important role as one of major primary energy supply system in the year 2050.[9]

Biomass resources are potentially the world's largest and most sustainable energy source - a renewable resource comprising 220 billion oven-dry tons (about 4 500 EJ) of annual primary production.[10] The estimated annual bio-energy potential is about 2900 EJ, though only 270 EJ could be considered available on a sustainable basis and at competitive prices. Despite its huge potential and the difficulty of obtaining accurate data on biomass resources a resort to satellite data imagery may help estimate the vast area to be covered and the changes over time for data collection.

Many problems remain in the collection and delivery of the amount of supply of these potential resources as compared to oil and gas. Although data from different sources may differ from different sources, potential resources may be estimated using conversion factors such as those recommended by Wichakorn and Bundit (2004). Table 1 shows estimated biomass energy potential in the ASEAN region reported by the WEC (2001).

Biomass Conversion Technology — Solid, Liquid and Gaseous Fuels

Biomass can be converted into more useful solid, liquid and gaseous forms before being used as an ordinary fuel. Intact woody materials or agricultural residues usually have relatively low calorific value as compared to those from fossil fuel. A solid wood, for example, may have a calorific value of 16.3 MJ/kg which is much lower than diesel oil which has 43.1 MJ/kg. or coal, which has 26.3 MJ/kg (Stout, 1991). However, if biomass is transformed into bio-briquettes, its calorific value would increase between 13- 20 MJ/kg.[11] If converted to gaseous fuel 1 kg of rice husks, can produce about 44 Nm^3 of combustible producer gas.[12]

Table 1. Biomass Potential in some ASEAN Countries (million tons)

Biomass Type/	ASEAN Member Country		
	Indonesia	Philippines	Thailand
Sugar cane bagasse	6.5	7.0367	15.61
Rice husk	14.3	1.939	4.936
Coconut shells/fibres	2.1	5.638	n.a
Palm oil residues	8.5	-	n.a.

Source: Data extracted from WEC Report (2001).

Solid Biomass Fuels

Wood Wastes

Biomass as solid fuel can be produced using densification, pyrolisis, chipping or size reduction process. Pellets, biomass briquettes, and charcoal are solid fuels in this category. Characterization and standardization of these fuels may find potential applications in value added industries particularly to uplift the standard of living of the rural population in ASEAN countries.

Wood wastes such as sawdust or rice husks can be used directly as solid fuel for cooking, drying or other thermal processes using a simple stove. A used oil drum or a combination of a biomass stove and heat exchanger can provide a relatively constant heating temperature for drying agricultural and marine products.[13] Battacharya et al. (2003) have discussed the potential benefit of the gasification-based cooking system in the ASEAN region using intact or processed biomass fuel. These stoves have a relatively higher thermal efficiency and are cleaner than that of the traditional cook stove.

Briquettes

Briquetting of biomass has been studied extensively within the FAO Regional Wood Energy Development Programme (RWEDP) in Asia.[14] Basically the briquetting process produces solid biomass fuel with density between 1-1.2 g/cc using the Japanese design Shimada Screw Press (40 Hp) with different hard facing alloys for the screw in order to extend its service life. Tungsten carbide was the best hard facing alloy for the screw. Preheating of raw material to be densified ha a significant effect on the screw life.[15]

Briquetting of biomass residue has been conducted at the Laboratory of Energy and Agricultural Electrification, Department of Agricultural Engineering, IPB.[16] Bio-briquettes from different kind of biomass wastes are made using the following procecure: Raw materials, dried and ground after sorting from foreign materials are fed into a pyrolysis reactor to produce charcoal. The charcoal flour is pressed using a simple manual press. Dried rice husks as raw materials are directly fed into a mechanical press to produce bio-briquettes.

The resulting briquette samples were then tested using the bomb calorimeter to determine their respective calorific values (CV). Corn cob and waste sludge bio-briquettes had the highest and lowest CVs, respectively (Table 2).

Table 2: Performance of the Briquetting Plant at IPB

No	Raw material for briquette production	Heating value (KJ/kg)
1	Sugarcane waste (sludge) briquette	17638
2	Rice husk charcoal briquette	13290
3	CPO waste (sludge/mud) briquette	10896
4	Saw dust briquette	18709
5	Grass briquette	16247
6	Coconut shell charcoal	18428
7	Corn cobs	15455
8	Corn cobs charcoal briquette	20174
9	Wood fuel (acacias)	17270
10	Bamboo	17503

Source: Augustinah (2007).

Wood Pelleting

Another method of densified biomass fuel making is pelletting. Wood pellets of compacted biomass increase make it more economic to transport over longer distances. Most pellets are made from sawdust and ground wood chips that are waste materials from house construction, furniture making, lumber, and residues from other activities that use wood.

Commercial pellets are sold in cylindrical form with (5-6 mm in diameter and 15-25 mm in length) with moisture content of 7-8 per cent (wet basis). Such pellets are suitable for wood stoves designed for space heating in countries located in cold regions. Some cooking stoves can produce a cleaner flame compared to that of the traditional stove. Beside wood chips and shavings, grass, nut shells, straw can also be used as pellet materials. Another type of stove which uses intact biomass materials such as cut twigs, fire wood is the Anagi stove developed in Sri Lanka by the Ceylon Electricity Board in 1986 and promoted by the ICS network of ARECOP.[17] The two-pot single-piece stove with a claim of 21 per cent efficiency has been produced and distributed to villages in the region through the ARECOP improve cook stove network.

Liquid Biomass Fuels

Pyrolysed-derived Biomass Fuels

The theory of pyrolisis of solid biomass has been described in great detail by Stout (1991) and Manurung (2003). The problem in defining the pyrolisis process is that it is process-oriented in time used both for char and tar processes.

Rice is a major crop in many ASEAN countries. About 20 per cent of the harvest is in the form of rice a husk which biomass resource is usually dumped or burnt near rice mills and that causes environmental pollution. Conversion into useful materials such as the Carbonized Rice Husk (CRH) or into solid, liquid and gaseous fuel via pyrolisis is recommended to counteract pollution. Pyrolysis of rice husks with a fixed bed converter has been studied thoroughly in Indonesia. A small pilot plant using rice husks as a feed has been established at the Bandung Institute of Technology (ITB), Indonesia[18]

Conversion of biomass into liquid fuels is also achieved through:

i) Fermentation of ethanol from sugarcane, cassava, rice;
ii) Synthesis of producer gas and from wood to produce methanol;
iii) Extraction of oil from seeds.

Plant Oils

The potential of plant oils as biofuels in the region to reduce the pressure of the oil crisis in the region has been considered only recently by ASEAN member countries. Indonesia, Malaysia, Thailand and the Philippines have launched national programmes to grow millions of hectares of palm oil plantations, the physic nut (*Jatropha curcas*), coconuts and various seeds. However, till to date individual ASEAN member country data on the availability and productivity of such plant bioresources is still meagre. An entrepreneurial facility in Indonesia has already invested in bio-ethanol production in Sumatra using cassava and its residues as raw materials. Another Indonesian commercial entity that has its core activity in sugar cane plantation is investing in the physic nut plantation for biodiesel production.

The current practice in the oilseed extraction industry is to use screw pressing (expeller), hydraulic press or solvent extraction to separate the oil-bearing seeds from physic nuts (Jatropha)

Screw pressing of Jatropha can extract around 25 per cent of oil. The pulp cake of Jatropha after oil extraction is bioconverted into a gaseous fuel using an anaerobic digester. A recent test at the ITB showed that 1.5 m^3 of digester fed daily with 25 kg Jatropha cake + 25 litres of water produces biogas adequate to substitute kerosene for one rural household family of four.

Despite several efforts to use Straight Vegetable Oil (SVO) for biodiesel and bio-kerosene, there are several major problems in using unmodified plant oils as alternative diesel fuels. Use of SVO produces clogging of fuel lines and filters, polymerization of oil during storage, thermal or free radical polymerization in the combustion chamber, poor ignition and thickening or increased solids contamination of the lubricating oil. There are several sources of bio-diesel raw materials found in the ASEAN region.[19] These are:

1) ***Edible Sources:*** palm, coconut, peanut, *Moringa oleifera, Adenanthera pavonina, Carthamus tinctorius,* etc.,
2) ***Non-edible:*** *Jatropha curcas,* kapok, candle nut, neem (*Azadirachta indica*), *Calophyllum inophyllum,* kusum (*Schleichera oleosa*), *Bombax malabaricum, Jatropha multifida, Jatropha gossypifolia,* and many others.

Biodiesel blends used in the ASEAN region use the following: i) the Coconut Methyl Ester (CME) in the Philippines; ii) the Palm Oil Methyl Ester (POME) in Malaysia. Market products are: B20 in Indonesia; B10 in Malaysia, and B5 in Thailand.

Biomass Conversion to Ethanol and Methanol

Ethanol or grain alcohol is a good fuel for spark ignition engines. A heat value per liter of ethanol is nearly 20 MJ/litres, higher than that of methanol which is 15.88 MJ/litres. Ethanol and methanol are produced by completely different processes though using sometimes similar feedstock.

Ethanol can be made from molasses as a byproduct from the sugarcane industry and from wood chips through fermentation. When used as a gasoline blend, anhydrous ethanol as fuel can be graded up from 5 to 10 per cent in the ASEAN region. Whereas Indonesia has B10 and B15 for export to the US, the Philippines uses a 10 per cent bio-ethanol and 90 per cent gasoline mix.

Methanol or "wood alcohol" is synthesised by gasifying the feedstock to make a CO mix which is cleaned and pressurized in the presence of a catalyst to produce methanol that is used in transesterification of plant oil to produce biodiesel.

Biomass Conversion to Gaseous Fuel

Gaseous fuel from biomass can be produced through gasification or the biogas digester. Gasification is the conversion of carbonaceous solids in biomass into combustible gas, namely CO, by controlling or limiting the rate of oxygen (air) admitted to the fuel bed. Biogas is a product of the anaerobic digestion of biomass and is also commonly known as CH_4 (methane).

Biogas

Biogas is a product of the anaerobic digestion of biomass. This bacterial process is widely used in Indonesia and Malaysia, the Philippines, Thailand, and Vietnam. The amount of gas produced is dependent on the digester size, the volatile solids loading rate, the temperature within the unit and biodegradability of the feedstock. Mesophilic bacteria, one of the two methanogenic bacteria are most active at 35° C whereas the thermophilic bacteria are active at 54 °C.

Biomass Energy Conversion to Electricity

Direct Combustion

Power or electric generation from biomass is obtained through conventional direct combustion to produce adequate high pressure steam to operate a turbine to generate electricity A potential biomass resource is that of rice husks found abundanty in several ASEAN countries notwithstanding that this bioresource has a low caloric value. An example of rice husk power generation is in the Roi Et Province in Thailand.[20]

Conclusion

Biomass in the form of fuel wood, wood or agrowastes can be used directly for traditional food and cookies in cottage industries in the rural areas of ASEAN member countries. Electricity has been generated from waste rice husks.[21] It can also be used as the main heat source in rice processing industries as practiced in Thailand and Vietnam and as auxiliary heat in the solar drying system in Indonesia. Special furnaces fed with rice husk, corn cob or wood to supply heat for rough rice drying have been used in Vietnam. Commercial continuous fluidized bed dryer can be used to dry corn, rough rice and soy beans.[22]

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Marine Biotechnology: A Natural Biorefinery Source of Marine Products and By-products for Human Welfare

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Abstract: About 70 per cent of the earth's surface is covered by oceans and seas, and four-fifth's of all life forms inhabit this ecological niche. Therefore, the importance of marine organisms as a biorefinery technology resource is overwhelming. Till recently, from the bioresources of the deep ocean, once considered to be a 'biological desert', a number of new unique organisms have been discovered. This results from the use of improved sampling techniques and of modern molecular biological tools to reveal some of the recent developments and the biotreasures of the deep oceans with an emphasis on marine bioactive compounds.

Keywords: Marine biotechnology, biorefinery, microorganisms.

Introduction

Man has been using natural products as a source of food, fragrances, pigments, insecticides and medicines for centuries. Generally, terrestrial plants have served as the major source of medicinally useful products and these have been developed from a legacy of folk medicine. Joffe and Thomas (1989) estimate that about 25 per cent of all pharmaceutical sales are drugs derived from plant natural products and an additional 12 per cent come from microbial natural products. The marine biosphere encompasses a huge thermal range from freezing temperatures in Antarctic waters to about 350° C in deep hydrothermal vents, a pressure range of 1 atmosphere at the surface to 1000 atmospheres in the deep oceans, a nutrient range from oligotrophic to eutrophic conditions and extensive photic and non-photic zones. This extensive variability

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has facilitated extensive speciation at all phylogenetic levels from microorganisms to mammals.

The importance of marine organisms as a biorefinery technology resource is over-whelming taking into account that about 70 per cent of the earth's surface is covered by oceans and seas, and that four-fifth's of all life forms inhabit this ecological niche. Worldwide sales of marine biotechnology-related products during 2000 were estimated to be US $100 billion. Through the application of molecular biological techniques in studying marine organisms, many basic biological principles of relevance to both marine and terrestrial organisms are clarified and understood. Much of what is known about nerve transmission has been learnt using squid and its giant nerve axon. Likewise, the mysteries of vision have been unraveled through a study of the eye of the horseshoe crab, shark and skate. And, whereas the surf clam is proving to be an excellent model to study cell cycle and its regulation, the sea urchin on the hand is a key model for understanding the molecular and cellular basis of reproduction and development.

The deep ocean often considered a 'biological desert' is a gold mine of new unique organisms that have been discovered through the use of improved sampling techniques and modern molecular biological tools such as metagenomic approach, high throughput DNA sequencing, and computational genomics. More than 1.2 million new genes have been identified in DNA extracted from about 1.5 L surface sea water off the Bermuda coast.[1] Despite the fact that the biodiversity in the marine environment far exceeds that of the terrestrial environment, research into the use of marine biomass for biofuel production and of marine natural products as a reservoir of pharmaceutical agents is still in its infancy. This may be attributed to the fact that the deep ocean has never been seriously considered as a source of biofuels and to the lack of ethnomedical history and difficulties involved in the collection of marine organisms.[2]

Lessons from Physiology of Marine Organisms

Life originated from the seas.[3] Marine organisms through evolution developed very sophisticated physiological and biochemical systems. During adaptation to the terrestrial environment and notwithstanding several physiological changes that have taken place, the basic functions have been retained. The architecture of the shark liver is similar to that of the human liver. Also, it is interesting that the biochemical transformation that takes place in a shark's liver is similar to that occuring in a human liver.[4] Insulin from fish such as cod exerts the same hormonal activity in mammals as homologous insulin.[5]

Knowledge of the physiological and biochemical features of marine organisms might contribute to the identification of natural products of biomedical importance. For instance, a damaged optic nerve in fish begins to repair itself spontaneously whereas a rabbits injured optical nerve ceases to function and degenerates. An extract from a fish nerve will induce regeneration in a rabbit nerve.[6] Fish are found to be useful models for the study of factors involved in axon regeneration.[7] Marine metabolites, therefore, have a potential to correct abnormalities that occur in terrestrial animals.

Marine Microbes: As a Natural Refinery

Since the discovery of penicillin in 1929 some 10,000 and more of these natural products are reported to have biological activity inclusive of 100 microbial products that are in use today as antibiotics, antitumour agents and agrochemicals.[8]

The development of the fungal metabolite *mevinolin* for the treatment of high serum cholesterol and the bacterial metabolite FK-506 as an immunosuppressant illustrate the vast natural diversity of microbial natural products.[9] In spite of such successes in drug discovery from terrestrial microorganisms, marine microorganisms have received very little attention on account of the non-culturability of the majority (over 99 per cent) of marine bacteria.[10]

Marine toxins such as tetrodotoxin and saxitoxin are potent and specific sodium channel blockers and pharmacological studies with these toxins have played a major role in developing the concept of sodium channels in general and membrane channels in particular.[11] Recent studies have shown that these toxins may be produced by marine bacteria.[12]

There is increasing evidence that several anti-cancer compounds isolated from sponges or other marine invertebrates are actually produced by bacteria associated with these invertebrates. Bryostatins were initially isolated from a bryozoan, *Bugula neritina.* Putative type 1 polyketide synthase genes have been found in bacteria from colonies of *B. neritina* producing bryostatin and these genes are absent from bacteria associated with colonies of *B. neritina* that do not produce bryostatin.[13] Dolastatin isolated from the Indian Ocean seahare *Dolabella auricularia* has also been isolated from marine cyanobacteria.[14] Dolastatin-like peptides have been isolated from the cyanophyte *Lyngbya majuscula.*[15]

Metabolites from Marine Microalgae

Microalgae (phytoplankton) are the major primary producers in the marine environment and are fundamental to the marine food chain converting carbon dioxide into organic compounds that can be subsequently used by invertebrates and fish. Though there are over 10,000 species of microalgae, most of the investigations have focused on the Cyanophyta (blue-green algae now classified with the prokaryotic bacteria) and the dinoflagellates.

A series of novel polyether antibiotics - the most potent antifungal agents reported to-date, have been isolated from the marine dinoflagellate *Gambierdiscus toxicus.* One of these, gambieric acid A is 2000-fold more active than the clinically useful antifungal agent amphoterecin B and has only moderate toxicity to mice and cultured mammalian cells.[16]

Novel Compounds from Seaweeds

Seaweeds in different colours–green (*Chlorophyta*), yellow-brown (*Phaeophyta*) and red (*Rhodophyta*) abundant in intertidal zones and in clear tropical waters play a significant ecological role by providing food, protection, shade and substratum for marine life. Widespread in shallow waters and easily harvested, seaweeds were the first group of marine organisms to be investigated for their natural products.

A Philippine collection of the red alga *Portieria hornemannii* has yielded a novel cytotoxic penta halogenated monoterpene, halomon which exhibited one of the most extreme examples of differential cytotoxicity in the screening conducted by the National Cancer Institute (NCI), USA.[17] The NCI screen looks for selective toxicity in a human tumour cell line panel consisting of 60 different cell lines representing eight major cancer subtypes. NCI has selected halomon for preclinical drug development since this compound shows toxicity to brain, renal and colon tumour cell lines and preliminary *in vivo* evaluations have been encouraging.[18] Though getting sufficient quantities of the chemical from the alga has been difficult, its mode of action as an inhibitor of DNA methyltransferase has been elucidated.[19]

An Australian red algal sample *Hypnea valitiae,* a novel potent and specific inhibitor of adenosine kinase was used to study adenosine receptors, nucleotide metabolism and regulation.[20]

Many red, green and brown algae convert simple polyunsaturated fatty acids such as arachidonic acids into complex eicosanoids[21] and related oxylipins.[22] Derivatives of arachidonic acid are important in maintaining homeostasis in mammalian systems.

Metabolites from Sponges

Sponges were recognized as a source of biomedically important metabolites following the discovery of spongouridine,[23] a potent natural occurring tumour-inhibiting arabinosyl nucleoside in Caribbean sponge, *Cryptotethia crypta.*

Several bioactive compounds with anti-inflammatory, antitumor, immunosuppressive or neurosuppressive, antiviral, antimalarial, antibiotic, or antifouling activity have been discovered from sponges (Table 1). Over 5000 medically important compounds from sponges have been described from amongst the 15,000 and more from marine organisms that have been recorded.[24]

A number of metabolites from sponges are proving useful as molecular probes in biochemical studies.

Terpenoides[25] involved in inhibiting inflammatory response have been isolated from *Jaspis splendens* and *Suberea* spp.[26] For example, discodermolide from the Caribbean sponge *Discodermia dissoluta* is 100-1000 times more potent than the drug cyclosporine A *in vivo* and other clinically useful immunosuppressive agents.[27] A number of receptor antagonists[28] with potential as biochemical tools lead to the development of therapeutics such as xestobergsterol from the Okinawan sponge *Xestospongia bergquista.*[29] Other significant sponge-derived therapeutics are leucettamine from the marine sponge *Leucetta microraphis.*[30] Several sponge-derived antimalarial compounds have been discovered for treating malaria caused by the chloroquinone-resistant malarial parasite.[31] Menzamines are most promising antimalarial compounds discovered from sponges.[32]

Table 1: Examples of Some Biomedically Important Metabolites from Marine Organisms

Organisms	Metabolite	Potential uses
Marine bacteria	Mevinolin FK-506	Treatment of high serum cholesterol Immunosuppressant
	Macrolactin A	Antitumour activity, protection against HIV, Herpes simplex virus types I and II.
	Tetrodotoxin	Study of sodium channel
Lyngbya majuscula	Lyngbyatoxin A, debromoaplysiatoxin	Study of Proteinase kinase C, signal transduction pathways, development of tumour suppressing compounds
	Microcolin A & B, curacin A	Immunosuppressant anti-tumour activity
Marine algae *Alexandrium tamarense*	Saxitoxin	Study of sodium channel, neurophysiological and neuro-pharmacological studies
Ptychocentrum brevis	Brevitoxin	Molecular probe in studies on sodium channel.
	Gambieric acid A	Antifungal compound
Prorocentrum sp.	Okadaic acid	Study of regulatory phenomenon and signal transduction pathways
Green algae	Spingosine derivative	Antiviral activity
Brown algae	Stypoldione	Antitumour activity
Red algae	Halomon	Antitumour activity
Sponges	Spongouridine	Antitumour activity
	Dercitin	Antitumour activity
	Halichondrin B	Antitumour activity
	Theopederin	Antitumour activity
	Cribrostatin 1	Antitumour activity
	Spongistatin	Antitumour activity
	Calyculin A	Antitumour activity
	Purealin	Studies on actin polymerization and actin organization
	Manoalide	Study of structure and conformation of myosins.
	Latrunculin A	Study on the role of phospholipase A_2 in inflammation
	Discodermolide	Immunosuppression
	Xestobergsterol A	Inhibition of lgE mediated histamine release from mast cells
	Leucettamine A	Anti-inflammatory activity
	Batzelladine A& B	Therapy of HIV

Table 1 continued

Table 1 continued

Organisms	Metabolite	Potential uses
Cnidarians [i]	Palytoxin	Cellular recognition process.
	Lophotoxin	Neuropharmacological probe.
	Pseudopterosin E	Anti-inflammatory activity
	Fucoside A	Anti-inflammatory activity
Bryozoans [ii]	Bryostatin	Antitumour activity
	Convolutamide A	Antitumour activity
	Flustramine E	Antimicrobial activity
Molluscs [iii]	Conotoxins	Study of ion channel
	Dolastatin	Antimicrobial activity
	Chromodorolide A	Antimicrobial and cytotoxic activity
Ascidians [iv]	Didemnin B	Antitumour activity
	Ecteinascidin 743	Antitumour activity
	Eudistomin C	Antiviral activity
	Staurosporine derivatives	Study of cellular differentiation & proliferation.

Source: Jha, R. K. and Zi-rong, X. (2004).

Molecular Probes from Cnidarians

The discovery of prostaglandins from corals in the late 1960s contributed greatly to the rapid developments in the field of marine natural products.[37] Palytoxin, one of the most potent non-protein toxins known and obtained from the cnidarian *Palythoa sp.*, is a useful tool for probing cellular recognition processes such as sodium and potassium ATPase binding and opening of the ion channel. Cosmetic companies have incorporated extracts from *P. elizabethae* into skin, hand and eye creams.[38]

Drugs from Bryozoans

The drug from the marine environment that is closest to the market may be bryostatin, a potent anticancer compound obtained from *Bugula neritina*,[39] while the New Zealand bryozoan *Cribricellina cribraria* has yielded a b-carboline alkaloid that has cytotoxic, antibacterial, antifungal and antiviral activities.[40] Biochemical entities from the Canadian water bryozoan *Flustra foliacea* have shown strong antimicrobial activity.[41] Novel cytotoxic quinones and alkaloids have been isolated from the bryozoans *Caulibugala intermis* and *Pterocella vesiculosa* respectively.[42]

Biochemical Probes from Molluscs

The predatory *Conus sp.* such as *C. geographus* have evolved deadly nerve toxins. These conotoxins are valuable probes in physiological and pharmacological studies.[43] Dolastatins are compounds obtained from the sea hare, *Dolabella auricularia*.[44] Carnivorous molluscs concentrate secondary metabolites from their selective diet of sponges, bryozoans, ascidians and coelenterates. Ulapualide A from *Hexabranchus sanguineus* exhibits cytotoxic activity against murine leukaemia cells and antifungal activity.[45]

Bioactive Molecules from Ascidians

Didemnin-B from the Caribbean tunicate *Trididemnum solidum* was the first marine compound to enter human cancer clinical trials as a purified natural product[46] which provided important structural clues for a variety of antiviral, anticancer and immunosuppressant activities.[47]

Metabolites from Echinoderms and Fish

Physiological active saponins have been studied extensively from echinoderms such as seastars and sea cucumbers.[48] However, they have not been useful as biochemical tools or drugs because of their tendency to cause cell lysis.[49] Squalamine, a member of the new class of water soluble broadspectrum antibiotics, has been isolated from the stomach extracts of dogfish shark, *Squalus acanthias*. This active entity is an aminosterol, which has shown promise as a part of combination with standard agents in clinical trials for non-responding solid tumours and in primary treatment for advanced ovarian cancer.[50]

Problems and Future Prospects

The vast potential of marine natural products that contribute to the development of biomedically important compounds has been well recognized. Trials with several compounds have progressed rapidly as a result of collaborative efforts between marine chemists, cell biologists and molecular pharmacologists. The development of automated high throughput screening methods allows researchers to test up to thousand compounds a day. However, a number of problems remain. Microorganisms maintained in artificial media may lose the ability to produce biologically important molecules.[51]

Biofuels from the Oceans

Several Asian countries are engaged in pursuing biotechnological options to lessen their dependence on imported fossil-fuel energy sources to help conserve valuable foreign-exchange resources, minimize environmental pollution and degradation of the quality of human, animal and plant life. Alternative sources such as agro-industrial residues and non-edible plants are being bioconverted into biofuels either as biogas, bioethanol or biodiesel. Marine biomass, hitherto untapped for such bioproducts now constitutes a new bioresource. "Man-made nutrient pollution" that harms the marine ecosystem gives rise to massive algal blooms that are being harvested to produce ethanol - a clean and non-polluting biofuel.[52]

Gao and McKinley (1994) view biomass production from macroalgae for CO_2 bioremediation and providing economically feasible technologies as alternatives to fossil-derived fuels. Several countries are moving into the area of using clean and green technologies from biomass feedstocks obtained from marine seaweeds and saline agriculture.[53]

The potential of using macroalgae from the Adriatic and Jonian seas for energy and biofuel production has been assessed.[54] Furthermore, a fully integrated process for biodiesel production from microalgae in saline water aims to demonstrate the technical and economic feasibility of using microalgal oils as a feedstock for biofuel.[55]

Conclusion

The discovery that many of the bioactive compounds isolated from invertebrates are produced by bacteria raises the hope that technology can be developed to produce these compounds in fermenters. However, culturablity of some of the sponge associated bacteria has been a problem. Another promising approach towards producing biomolecules is recombinant DNA technology. Recently, genes involved in the synthesis of pederin, a polyketide amide present in beetle, *Paederus fuscipes* has been cloned.[56] Interestingly, pederin is closely related to mycalamide A from the marine sponge *Mycale* sp. Such approaches are expected to yield results soon and it can be expected that a number of useful drugs would come from the marine environment.

With the advances in diving technology and the availability of remotely-operated vehicles and submersibles, samples of marine organisms from depths of even 1000 m and beyond have been obtained. Many of the organisms are unique and this has provided an additional stimulus to the search for marine bioactive compounds and perhaps of biofuels from marine biomass. During 1977-1987, a wide variety of marine organisms yielded some 2500 new metabolites.[57] During 2003-2004, the structure and initial bioactivity profiles of more than 150 marine natural products with antitumour and cytotoxic activity have been described.[58] Many of these compounds are novel belonging to diverse structural classes including polyketides, terpenes, steroids and peptides.

Endnotes

[1] Venter et al. (2004).
[2] Faulkner (1992).
[3] Where did life originate? (http://evolution.berkeley.edu/evosite/evo101/IIE2aOriginoflife.shtml)
[4] Ballatori and Villalobos (2002).
[5] Reinecke and Collet (1998).
[6] Halevy (1990).
[7] Schwalb et al. (1995).
[8] Carte (1996).
[9] Carte (1996).
[10] Hugenholtz and Pace (1996).
[11] Camacho et al. (2007).
[12] Kodama et al. (1990), Simidu et al., (1990).
[13] Davidson et al. (2001).
[14] Luesch et al. (2001).
[15] Newman and Cragg, (2004).
[16] Nagai et al. (1992).
[17] Carte (1996).
[18] Carte (1996).
[19] Andrianasolo et al. (2006).
[20] Ireland et al. (1993).
[21] Eicosanoids (eicosa in Greek means twenty) are oxygenated derivatives of 20 carbon essential fatty acids. There are four families of eicosanoids, prostaglandins, prostacyclins, thromboxanes and leukotrines.
[22] Oxylipins are oxygenated compounds biosynthesized from fatty acids by the action of dioxygenase catalysed oxygenation.
[23] Terpenoids: terpenes are hydrocarbons with combination of several 5 carbon isoprene units, terpenoids are modified terpenes, where methyl groups are moved or removed and oxygen atoms are added.
[24] Sipkema et al. (2005).
[25] Spongouridine, is an antiviral nucleotide derived from Cryptotethia crypta.
[26] Carroll et al. (2001).
[27] Longley et al. (1991).
[28] Receptor antagonists: Agonist is a substance that binds to a specific receptor and triggers response in a cell. Antagonist blocks the binding of the agonist to the receptor.
[29] Shoji et al,(1992).
[30] Chan et al. (1993).
[31] Sipkema et al., (2005).
[32] Yousaf et al., (2002).

[33] Cnidarians, all armed with stinging cells called nematocysts, are diverse in form, as evidenced by colonial siphonophores, massive medusae and corals, feathery hydroids and box jelly's with complex eyes. The name Cnidaria comes from the Greek word "cnidos" that means stinging nettle. There are four major groups of cnidarians:
— Anthozoa which includes true corals, anemones, and sea pens;
— Cubozoa, the box jellies with complex eyes and potent toxins;
— Hydrozoa, the most diverse group with siphonophores, hydroids, fire corals and many medusae; and
— Scyphozoa, the true jellyfish. (http://www.ucmp.berkeley.edu/cnidaria/cnidaria.html)

[34] Bryozoans a group with a fossil record extending back to the upper Cambrian [500,000,000 years ago] known also as moss animals are tiny colonial animals that generally build stony skeletons of calcium carbonate. Except for the class Phylactolaemata which is found exclusively in fresh water the majority of bryozoans are marine (several thousand species).
1] http://www.bio.umass.edu/biology/conn.river/bryozoa.html
2] http://paleo.cortland.edu/tutorial/Bryozoans/bryozoans.html

[35] Molluscs, a variety of animals with decorative shells that vary in form and colour are well-known as seafood and which range from tiny snails, clams, and abalone to larger organisms such as squid, cuttlefish and the octopus. Malacology is the scientific study of molluscs. The vast majority of molluscs live in marine environments mainly on the coastal plains. Two groups, viz the bivalves and the gastropods contain freshwater species. The gastropods are the only group that have snails and slugs as representatives living on land. (http://www.mesa.edu.au/friends/seashores/molluscs.html)

[36] Ascidiacea, commonly known as ascidians or sea squirts. The common name sea squirtarises from their habit of squirting a jet of water when stamped upon or when they are uncovered at low tide. Ascidians, soft and boneless, possessing a sac-like marine filter feeder and a tough outer "tunic" made of the polysaccharide tunicin are found all over the world usually and firmly attached to substrata such as rocks and shells. (http://www.seaslugforum.net/factsheet.cfm?base=ascidian)

[37] Carte (1996).

[38] Liles (1996).

[39] Liles (1996).

[40] Prinsep et al., (1991).

[41] Holst et al., (1994).

[42] Yao et al., (2003); Milanowski et al., (2004).

[43] Myers et at., (1993).

[44] Newman and Cragg, (2004).

[45] Rorsener and Scheuer (1986).

[46] Carte (1996).

[47] Sakai et al., (1995).

[48] Miyamoto et al., (1990).

[49] Carte, (1996).

[50] Newman and Cragg, (2004).

[51] Gustafson et al., (1989).

[52] Harvesting algae blooms from the open ocean, Thursday, March 1, 2007, (http://biopact.com/2007:03/Harvesting.Algae.Blooms;from.Ocean.html)

[53] Sakurai and Masukawa, (2007).

[54] Aresta et al, (2005).

[55] Project ID: RDG-07-26 Application for AP6 Project Inclusion in Renewable Energy and Distributed Generation Task Force of the Asia Pacific Partnership on Clean Development and Climate (www.asiapacificpartnership.org/APP%20Projects/

REDG/Project%20Proposal%20-%20AUS%20-%20Microalgae%20_3_.pdf) The Asia Pacific Partnership on Clean Development and Climate (AP6) is a breakthrough approach involving key developed and new industrializing countries in practical, pro-growth, technology-driven efforts in clean development and climate change through deployment of clean technologies. The partnership of the six countries - Australia, China, India, Japan, Republic of Korea and the United States was established in January 2006 in Sydney, Australia

[56] Piel, (2002).

[57] Ireland et al., (1993).

[58] Mayer and Gustafson, (2006).

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Renewable Energies for North and Central Asian Countries: Bioeconomics, Environment and Social Impact

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Abstract: Decentralised cooperation at the level of Cities[1] is important: local administrations are responsible for implementation of programmes and their real (positive or negative) impact on local communities. These are inclusive of adaptation and mitigation of global warming and climate change due to Greenhouse Gas (GHG) emissions. At the local level the benefits created by efficacious implementing of sustainable investments at Energy Agencies or Energy Service especially for investors can really be recognised. This strict connection with local investors also suggests different financial instruments that can define and record the evidence and relevance of environmental and social implication rather than financial results. Defined as the "Kyoto Bond"[2] double parallel accountings will show the real value of non financial performance that, summed to fixed earning, is higher than market medium performance.

Keywords: Renewable energy; Asia; bioeconomy; society.

Introduction

The World Summit on Sustainable Development (WSSD)[3] strongly reaffirmed the commitment to the Rio principles, the full implementation of Agenda 21[4] and its programme for implementation thus committing nations to achieving internationally agreed development goals inclusive of the United Nations Millennium Declaration *(UN "Millennium Declaration", 2000 – New York)* through the "Plan of implementation" *(UN "WSSD Ministerial Declaration", 2002, Johannesburg; UN "Johannesburg Plan of Implementation" (2002),*

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Johannesburg). The three components of sustainable development as interdependent and mutually reinforcing are:

- economic development;
- social development; and
- environmental protection.

After WSSD, Public-Private-Partnership[5] was one of the main results targeting concrete implementation of policies and measure especially related to relevant themes such as energy, Energy Efficiency (EE), and Renewable Energy (RE). In providing a basis for economic development and basic services like health care, education and communication people need to access reliable and affordable energy supplies that can meet the gap even in countries where there is a serious lack of energy infrastructure (electricity grid).

Renewable Energy (RE) and Bioeconomic Considerations

RE can play a significant role in counteracting global warming, diminishing air pollution, diminishing dependency on energy imports, providing energy functions to poor rural and isolated areas without energy services and ensuring security of supply in a cost effective way in remote or non-grid connected areas with no energy services nor local sustainable energy sources.

RE comes in many forms, maturities and prices. It can be the cheapest of energy technologies because it is mature; as in the case of wind power (where the energy supply costs – capital and operational - are comparable with fossil fuel costs), the market rules are reasonably favourable, and the resources are strong. In many cases such as Photovoltaic (PV) Concentrating Solar Power (CSP), RE can be very expensive since the technology is less mature in terms of costs for investments, difficulties to find raw material such as the mono or poly silicon, and the market rules are not so favourable.[6]

New market mechanisms like the trading of emission reductions or the Trading of Renewable Energy Certificates (TRECs) offer some attractive advantages (Hamrin and Wingate, 2003; International Conference for Renewable Energies, Bonn, 2004). With the use of tradable certificates, RE investments can be made where resources are most favourable and costs are lowest such as in the North and Central Asian Countries[7] where available space, public acceptance, and accessibility to consumers clearly contribute to development, socio-economic improvements and energy security.[8] International markets provide economies of scale, causing even lower costs, faster development and faster market uptake of RE technologies.

RE has a wide range of technologies to generate electricity with renewable sources such as biomass, agriculture by-product and waste, landfill gas amongst several others such as hydro and geothermal resources; another emerging sector is that of bio-fuels, i.e. bio-diesel from oil seeds and bio-ethanol from agriculture residues; and sustainable heating systems that use heat generated from combustion of biomass, from biomass fuelled CHP, from solar heating of form geothermal sources. In unlocking their RE potentials developing countries make use of additional income streams from industrialised countries through several mechanisms such as the carbon finance which does not exist at present as do the global markets for oil.

A global market for renewable energy does not exist at present like the global markets for oil and that of Carbon Emission Reductions (CERs) created by the mandatory target of the legal binding Kyoto Protocol.[9] The main reasons for this absence of a global RE market results from home markets for the RE industry development policy, a large geographical spread of optimal RE resources, lack of an infrastructure for transport and trade of RE and also because some RE technologies are still out of the market with high costs.[10]

RE technology can reduce significantly costs resulting from market experience and that may over time overcome the cost barriers and lead to profitable investments. Individual companies and governments may, however, have incentives to free ride and wait for other stakeholders to bring the technological development further. Private companies cannot appropriate all the benefits of their innovation, product and process improvement.[11]

Private returns on R&D across various sectors are between 20-30 per cent, while social rates of return are around 50 per cent. This shows that private investors only appropriate a fraction of social returns because technology 'spill over' in the energy sector is large. Investors also face difficulties in evaluating intangible research and development output and therefore under-invest in research and development.[12]

As a result, research and development intensive companies are systematically under-priced by the market and likely to reduce the incentive to perform basic research. Furthermore, energy technologies are usually sold to markets that are closely regulated. A path-breaking research success is likely to induce a change in the market design or regulation, so that the public appropriates the profits and not the private innovator. Therefore, it is generally accepted that public support is required to achieve an optimal R&D level.

The importance of R&D also supported by macro-economic analysis which has show that increasing research and development expenditures in carbon-free technologies could crowd out R&D in the rest of the economy and reduce overall growth rates.[13]

Industry-funded R&D focuses on the areas of existing activity of a company. The market volume of renewable energy technologies is still small, and therefore industry R&D is likely to be small. Furthermore, even forward-looking companies do not plan for more than a decade and are therefore likely to focus on improvements that can be leveraged short term in about 5 years. That is reasonable for an economy but not for energy.[14]

Climatic Change and related Aspects

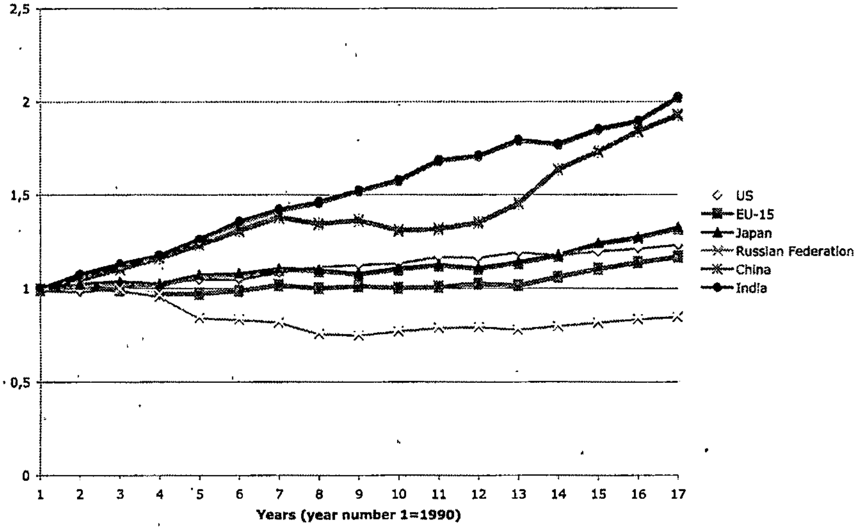
The Fourth Assessment Report of the IPCC[15] in 2007 reports that emission growth will accelerate the increase of CO_2 concentration in the atmosphere, which is a source of a danger for the climate system as dramatically shown by Katrina and other extreme weather events during 2005. Since the industrial revolution, CO_2 concentrations in the atmosphere have increased by more than 30 per cent, reaching a level of about 380 part per million in volume (ppmv).[16] This increase is, at least, partially responsible for the climate variability of the last decades.

In order not to drastically modify the natural systems and the mountain, glacier and coastal areas, as per IPCC indications, stabilization of CO_2 emissions should not increase the average temperature and sea-levels. By the year 2100, a concentration of CO_2 at 550-650 ppm is considered as the achievable target to contain an increase of the average temperature below 2°C and the rise of sea level below 20 cm.

The "stabilization scenarios" of IPCC predict, at least until 2030, an increase in emissions due to growing fossil fuel consumption in the short-medium term.

The reduction of 5.2 per cent of GHG levels of 1990, expressed in CO_2 equivalent, from developed countries required by the Kyoto Protocol is an important starting point to prevent the climate change and to start new sustainable energy policies for a sustainable economy. IPCC foresees a global emission reduction by 50-60 per cent, compared to 1990 levels, to be reached in the timeframe 2020-2050, so to ensure the stabilization of CO_2 concentrations within a safe range by the end of the century (Figure 1 shown as the emissions in developing countries will rise tremendously and strong policies and innovative financial arrangements are needed).

Figure 1: Emission of principal emitters of the world compare with the 1990 levels



Source: Author elaboration from UNFCCC, Eurostat, and IEA data, 2006.

It is clear that from 2020 the supply of energy will also need to be provided by a wider use of renewable energies, hydrogen technologies and fuel cells, highly efficient "clean" technologies with an "exit strategy to oil". Policy makers are now seriously considering the issues of implementation of renewable targets to meet 'Kyoto compliance' and a level of independence from fossil fuels that will increase in the future the price in the international markets.

At the local level concerning Region to Cities lower cost/risk portfolios can be developed by adjusting the conventional mix through inclusion of greater amounts of fixed-cost renewable and that coming from the "carbon finance". It is well-known that adding fixed-cost generating technologies to a fossil generating portfolio serves to lower overall generating cost and risk.[17]

Policy makers consider the additional income economical and environmental benefits from the TRECs or CERs or other "energy commodity" as a certificate to avoid pollution from GHG for implementation at the city level. However, in the context of a global energy and "energy commodity market an energy source mix of an Energy Efficiency (EE)) and a Tradable Renewable Energy Certificates system can be implemented locally in harmonization with existing trading systems.

Fostering the Use of Renewable Energies

Governmental support schemes for RE at the national level are not new in the EU. Leaving aside the vast field of state investment grants for RE production mostly for wind or solar power the first wide-ranging support schemes have a long tradition as well. After the first schemes in Portugal (1988), the Netherlands (1989), and Germany (1990), all member countries have followed the lead and implemented support mechanisms (EU Commission, 2005). Perhaps, the Central and Eastern European countries will adopt the use of renewable energies.

At the European level, the regulatory framework established in 2003 with the second package of Directives for the single energy market is now nearing completion (EU Commission 2003). The Italian legislation is oriented to increase the share of renewable energies (RES) in the internal market of energy assuming that the Kyoto Protocol and the European Directives are the bases for the Italian goals. These goals are not easily obtainable on account of the structure of the Italian industrial sector which is less energy intensive than other European countries. Moreover, the high price of electricity generation is partly explained by the market that has still to feel the full effects of liberalisation and competition. This means that the industrial sector will discount the enormous costs concerning the Kyoto target and the energy supply that will be too strong an effort for the entire economic system. On the other hand, the Kyoto commitments should be reached in an economic manner. So, the most appealing question to the Italian Government and others for the next six years is: *who does pay for Kyoto?*

If the roles are not yet clearly identified, the actual scenario finds several economic tools that can support the increasing of REs and energy efficiency that could comply with the Kyoto Protocol. However, many of these actions are not oriented to small-medium enterprises and households needs and thus cannot be used to reach an improved "energy lifestyle". One of the main features of the Italian economy is the ability to build complex systems of integrated small and medium enterprises — a "production district", able to concentrate, in a portion of territory many enterprises linked to each other and specialised in one kind of production in consonance with the life cycle assessment and in a position to contend in the global market. In the environmental economy, the benchmark represents a serious added value to learn from some other experiences already implemented at the ground level. Therefore, the quoted experiences at the EU level such as the TRECs experience[18] could be a benchmark to stimulate something similar but with the peculiarity needed in Central Asian countries. The experience of small and medium enterprises in Italy is a good practice of an acceptable sustainable approach to the environment.

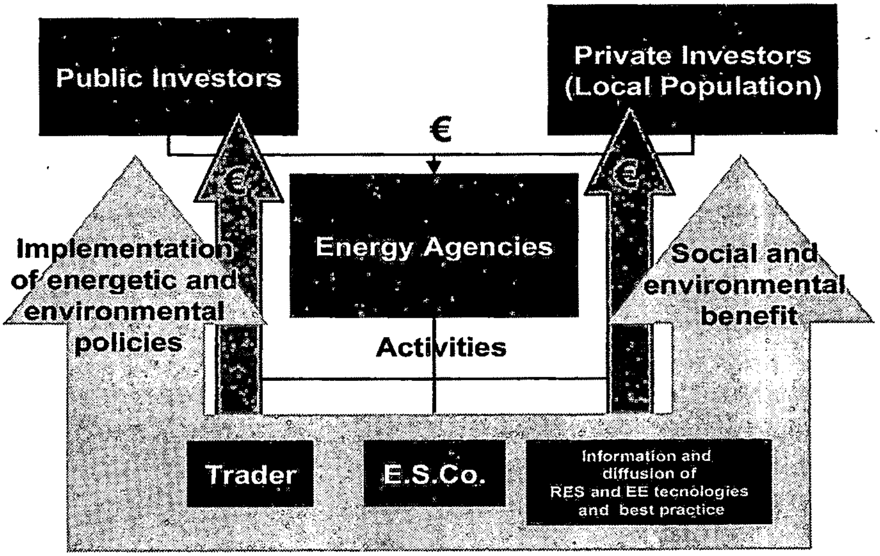
Under the SAVE programme[19] — a programme to promote among EU Member States the rational use of energy and energy efficiency in industry and the building sector, the European Commission has financed the setting up of regional and local energy management agencies and in the few years many agencies have been established all over Europe inclusive of countries in Central and Eastern Europe. The roles of these agencies consist in informing about and supporting the strengthening of the renewable energy markets but which until now are not able to compete with traditional sources of energy. In addition, many of them are short of funds to implement programmes in an effective manner.

The need of capital for Energy Agencies is primary; implementing programmes and policies requires high financial supply and the investments require a long term to create profits. In addition, citizens often don't realise how these agencies are the means to reach a greater level of benefits when the programmes are well implemented and efficaciously executed. The agencies structured like the SAVE programme are not able to reach the entire population and or the Kyoto targets because they do not have enough financial and technical supports to generate adequate benefits and projects.

However, the energy agencies, that can be implemented also in North and Central Asia as Energy Service Company (ESCO), could have a more important role if they could collect both public and private capitals and operate as a public company with a wide shareholder base: in this way they could operate at a local level supported by the local population that would became shareholders and, at the same time, be beneficiaries of energetic programmes.

Moreover, public involvement is able to link the implementing activities with policies and programmes at the regional and national level, while private participation would ensure capital requirements for the takeover of the activities. In Figure 2, the possible structure is explained to implement RE at a local level with a Public-Private partnership driven by energy agencies or a energy service company that can play a relevant role at the local level in promoting sustainable energy and implementing the "Kyoto bond" as a energy commodity for RE or Energy Efficiency to replace fossil fuel sources affecting the climate and increasing global warming. A structure like the one represented in Figure 2 can also developed in Northern and Central European countries, and Eurasian countries, where the concept of public company is already well known.

Figure 2: Energy Agencies proposed structure and the sustainable energy project that can be implemented at local level (e.g. energy commodity trading, energy services (as ESCO - Energy Service Companies), information and EE and RE technology deployment and best practice) with global benefits on GHG


Public Investors
Private Investors (Local Population)
€
€
€
Implementation of energetic and environmental policies
Energy Agencies
Social and environmental benefit
Activities
Trader
E.S.Co.
Information and diffusion of RES and EE tecnologies and best practice

A company organized like this would permit the obtaining of social and environmental targets as well as monetary profits. At the same time, investments could be oriented to particular interventions that will spawn benefits and revenues in a long lapse of time. The strict connection with territory and local population is an important incentive to produce greater results in a more efficient manner: the investors reach two different results at the same time: economic, deriving from the return on investments; and social, coming from the increase of wellness connected to the results of activities implemented.

With greater financial support, and with the necessity of making profits, energy agencies must acquire a more important role in an energetic market with an operating role as a trader for all market based incentive mechanisms adopted to support REs and Energy Efficiency white and green certificates.[20, 21]

Bioenergy: An Option for North and Central Asia Countries

The potential role of bio-energy has been addressed more seriously in the last decade when global concerns related to energy prices, environmental degradation, privatization of the energy sector and the sustainability of current energy systems started to arise. An assessment to determine biomass potential production and cost supplies has been undertaken concerning huge land resources in Central and Eastern European countries. Opportunities for the Ukraine have also been considered.[22] Moreover, the state of sustainable wood management in Central and Eastern European countries has been assessed in 2005.[23] This year the Eastern Biofuels Conference reviewed the latest technological developments, feedstocks, export markets, carbon trading, policies, and financing of biofuel and biomass projects.[24]

Bio-energy in general and wood energy in particular are the dominant sources of energy for about half of the world's population who are the poorest, and who use this energy mainly for cooking, heating or lighting with bad and low efficiency. The population of rural and isolated areas of North and Central Asia have also a very limited or very expensive access to electricity and liquid fossil fuels for transport.

Increasingly, different kinds of energy crops and plantations are expected to provide the bulk of biomass for energy production and can offer benefits to agriculture.

The Kyoto Protocol and its mechanisms such as Joint Implementation (JI) (for Annex I countries) and Clean Development Mechanism (for non Annex I countries) does give credit for afforestation and reforestation projects and can stimulate a sustainable land use even in areas such as Russian Federation (e.g. Siberia Region and Kamchacta Peninsula), Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and Western China (Tibet), where the past use of agriculture was not so sustainable (Table 1).

Biofuels will be seen as a part solution for transport fuels but this may be limited by competing requirements for land use and water resources that can be preserved.

Biofuels are liquid and gaseous fuels produced from various forms of biomass and used to substitute conventional petroleum fuels. Bioethanol, biodiesel, biogas, dimethyl esters and synthetic fuels are included. This is particularly the case with first generation agricultural systems. Second generation technologies, not based on traditional crops grown for food, can help to develop systems using crop and forest residues and non-food crops with good potential in terms of scale economy and cost reductions. Additional support can come from policies that will include the Kyoto JI and CDM mechanisms and International Emission Trading to account for carbon benefits that can generate an additional income from producers and users of bio-fuels to shift from the usage of oil that has been predicted to end soon. This depends on future oil prices (not less than 70 US$ per barrel) and availability that is governed by geopolitics and which force Central and Eastern European countries to adopt a switch towards new liquid fuels like bio-diesel, bio-ethanol or an hydrogen-based economy.

In the EC's 1997 White Paper on Renewable Energy Sources, biomass represented 68 per cent of the EU's indicative target of doubling its share of renewable energy sources from 6 per cent of gross domestic energy consumption in 1998 to 12 per cent in 2010.[25]

However, in its more recent Biomass Action Plan, the EC highlighted that despite the existence of mature, straightforward and commercially viable technologies for renewable heating for residential and industrial purposes, the consumption of biomass is growing slowest in the heating sector.[26]

Many of the Central Asian countries can develop bioenergy and biofuels production for heating systems that represent a high part of energy consumption. Agriculture in Central Asia constitutes at least 20

Table 1: Bioenergy Initiatives in Former North and Central European Countries *

Year	Country	Goal	Activity
Biogas			
2000	Turkmenistan	Promotion ofbiofuel initiatives.	Ministry of Health and Medical Industry in a survey found that most rural households use biogasto meet their domestic energyneeds.
2002	Kyrgystan	Establishment of biogas units and a microhydro plant in the Kizil-Charba village, Talas region.	Power supplied to 22 households biogas units heated in the winter by electricity comingfrom the micro hydro plant that enable gas units to meet domestic energy needs and yieldfertilizer as by-product.
2003		Introduction of bio-gas plant in Nurmanbet village, Issyk-Kul region.	Provides local communitywith autonomous biosource of cheaper non-polluting energy.
2004	Kazakhstan	Establishment of Education Biogas Centre.	The biogas centre known as *AzureFlame* in Karaganda disseminates educational material concerning biogas technology in improving the economical, environmental and social situation of rural communities.
	Mongolia	Development of abiogas plant by a local enterprise through the Experimental Animal Research Centre of The Inner Mongolia University and Inner Mongolia Livestock Improvement Centre as a showcase model that can be replicated elsewhere in ruralareas of Mongolia.	Establishment of a breeding base of several million dairy cows in the Liangcheng County in the zone that includes: Hohhot and Jining -in Inner Mongolia, Ulaan Chab, and Daton in the Shanxi Province of China to control the spread of diseases; enhance rural electrification and enhance income -generating activities such as marketing of digester residue as soil conditioners and biofertilzers
2005	Uzbekistan	Establishment of a pilot biogas plant in Zangi-Ata Rural District, Tashkent Province.	Local farmers encouraged touse biogas as an environment-friendly technology and a clean low-cost biofuel which is linked to some 9340 farms that have cattle, sheep, pigs and chicken.
2006	Tajikistan	Promote the use of biogas as a fuel substitute for *Tapak* cakes made fromdried straw and cattle dung and which emitstoxic fumes harmful to human health of the inhabitants in Sharak village in the Muminabad district.	The aim of introducing biogas technology and allied process benefits is to improve the economical, environmental and social situation of rural communities.

* Data Contributed by Edgar DaSilva

per cent of the GDP of every Central Asian country with the lone exception of Kazakhstan. Despite this, in all of the Central Asian countries, at least 20 per cent of the labour force is employed in agriculture.

The two most significant crops in Central Asia are cotton and wheat. The emphasis on intensive cotton cultivation in the Amu Darya watershed countries of Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan has played a major role in the drying and polluting of the Aral Sea because of the large amounts of water and fertilizer used in cotton cultivation. The energy cultivation could avoid this mistake in future so as to reconstruct the wetland ecosystems.

Aside from these two primary crops, the region produces a wide variety of products which include barley, corn, flax, grapes, potatoes, rice, sugarbeets, sunflowers, tobacco, apricots, pears, plums, apples, cherries, pomegranates, melons, dates, figs, sesame, pistachios and nuts.

The key point for all these remote areas of North, Central and East Asia is to find new financial arrangements and economic tools to stimulate the RE and bioenergy deployment as a sustainable solution to heating, electricity generation and transport needs. The focus must be on the local and small community of citizens since the central governmental authorities can often forecast properly and promptly the local solutions, and provide the financial instruments that are needed.

Kyoto Bond: Economic Rent, Environmental Benefits and Citizens' Wellness

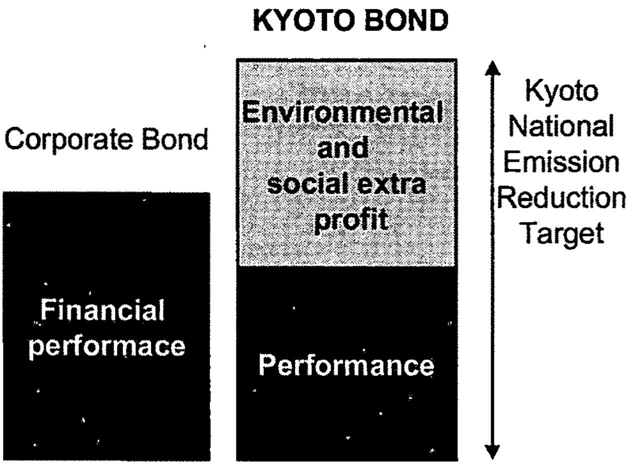
The author supports the importance of a wide shareholder base company to develop policies and programmes at the local level particularly in the Central and Eastern European countries. Energy Agencies could operate in the energetic markets and reach tangible results with environmental and social implications. The relevance of this solution is that the involvement of private funding would be limited to investors at the local level who can really recognise the benefits created by the efficacious implementing of sustainable investments.

This strict connection with investors' wellness also implies the creation of different financial instruments that can influence the relevance of environmental and social aspects of development. Labelled as the "Kyoto Bond" they would have the following objectives: capital collected would be invested in local projects that target the fulfilment of local energetic policies and give investors the opportunity to invest their savings for tangible and controlled operations. The performance of these instruments (as shown in Figure 3) has two different characteristics:

- Financial performance: fixed coupon bond with a lower percentage performance than other over the counter instruments;
- Non financial performance: the increase of social and environmental benefits deriving from National Energy Agencies activities.

Double parallel accounting would show the real value of non-financial performance that in relation to fixed earning is higher than market medium performance. Non-economic performance would be benchmarked with European targets of emission reduction derived by Kyoto approval.

Figure 3: The Proposed "Kyoto Bond


KYOTO BOND
Corporate Bond
Financial performace
Environmental and social extra profit
Performance
Kyoto National Emission Reduction Target

Conclusion

Local governments often meet with difficulties in implementing successfully European and national energetic policies and programmes which situation is often due to insufficient budgets assigned for local governance and the inadequacy of efficiency in public administration.

In this paper, the author suggests a different point of view that would increase efficiency of programmes that would enhance environmental and social benefits which results could be reached through:

- Involvement of public local investors
- Concrete programmes and efficient actuation
- Environmental and social benefits easily valued by local populations.

The proposed innovative financial scheme could be used for all remote areas of North, Central and East Asia to start up new energy tools to stimulate EE, RE and specifically bioenergy deployment as a sustainable solution to heating, electricity generation and transport needs.

Endnotes

[1] Cities are urban areas differing in size, population density, importance, or legal status from a town, village, or hamlet. !non financial performance which is the increase of social and environmental benefits derived from Energy Agencies activities.

[2] An original approach as conceptualized by the author in the *Kyoto Bond* would have the following characteristics:

- Capital collected would be invested in local projects that permit reaching the target of local energetic policies, and giving investors opportunities to invest their savings in tangible and controlled operations.
- The performance of these instruments is of the following types:
  - financial performance: fixed coupon bonded with a lower percentage performance than other over the counter instruments;
  - non financial performance which is the increase of social and environmental benefits derived from Energy Agencies activities.

[3] The World Summit on Sustainable Development, (WSSD) or Earth Summit 2002 was convened in Johannesburg, South Africa, from 26 August to 4 September 2002 to discuss with several leaders from national governments, business and non-governmental organizations sustainable development by the United Nations. WSSD was held 10 years after the first Earth Summit in Rio de Janeiro and was also informally known as "Rio+10"

[4] Agenda 21 a programme run by the United Nations (UN) concerns sustainable development; and is the blueprint of action to be taken globally, nationally and locally by organisations of the UN, governments, and major groups in every area in which humans impact on the environment. The number 21 refers to the 21st century.

[5] Public-private partnership (PPP), often referred to as PPP or P3, is a system in which a government service using tax revenue to provide capital for investment or private business venture is funded and operated through a partnership of government and one or more private sector companies through an established binding contract.

[6] IEA (2003 ; IEA (2006).

[7] Central and Eastern Europe is a strategic region for energy transit, linking Eurasian supplies with large consumers in Western Europe. The Central/Eastern Europe region is also a significant energy consumer, accounting for 35% of total European energy demand and is constituted of the following countries: Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Latvia, Lithuania, The Former Yugoslav Republic of Macedonia, Moldova, Poland, Romania, Serbia and

Montenegro, the Slovak Republic, Slovenia and the Ukraine. The region of Central Eurasia is constituted of the following: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia and Tajikistan.

[8] IEA (2003).

[9] The Kyoto Protocol!The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions. Only Parties to the Convention that have also become Parties to the Protocol (i.e. by ratifying, accepting, approving, or acceding to it) will be bound by the Protocol's commitments. To date 173 Parties have ratified the Protocol. Of these, 35 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5.2 per cent from 1990 levels in the commitment period 2008-2012. The Kyoto Protocol entered into force on 16 February 2005.

[10] IEA/GB (2003).

[11] Kilman (2001).

[12] IEA/RETD (2006).

[13] Goulder and Schneider (1999).

[14] Anderson and Bird (1992); Kilman, M. (2001).

[15] The Intergovernmental Panel on Climate Change (IPCC) has been established by WMO and UNEP in 1988 to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters.

[16] Part per million in volume (ppmv) indicate one particle of a given substance (e.g. CO2) for every 999,999 other particles, therefore one part in 106.

[17] Hamrin and Wingate, (2006).

[18] Hamrin and Wingate (2003).

[19] The SAVE Programme was the principal focus of the Community's non-technological action on energy efficiency and the only Union-wide programme dedicated exclusively to promoting energy efficiency and encouraging energy-saving behaviour in industry, commerce and the domestic and transport sectors through policy measures, information, studies and pilot actions and the creation of local and regional energy management agencies. The first SAVE programme was adopted by the Council in October 1991 lasted until 1995. SAVE II was adopted by the Council in December 1996 (96/737/EC) for the period 1996-2000. In February 2000 (647/2000/EC) SAVE was integrated into the Energy Framework Programme which outlined the Community's strategy for the five years period 1998-2002 (99/21/EC, EURATOM.

[20] White certificate represents the separable bundle of non-energy attributes (environmental, economic and social) associated with energy efficiency performance of final user or a supplier of primary energy or electricity. Green certificate represents the separable bundle of non-energy attributes (environmental, economic and social) associated with the generation of renewable power, and are sometimes also referred to as green tags, green tickets, renewable certificates, and renewable electricity certificates or credits (RECs). Both (green and white certificate) are used in many different contexts for different purposes. This fact sometimes creates confusion for those unfamiliar with the full range of their use. They are generally sold separately from their associated energy in wholesale markets. In retail markets they may be sold separately as an independent «product» or may be combined with electrical energy at the point of sale to create a renewable electricity offering. In several U.S. States, Europe (Italy, UK, Belgium, Sweden the

Netherlands) and Australia, those energy commodity are used as an accounting tool to measure and track renewable generation and energy efficiency achievement.

[21] Holt and Bird (2005).

[22] Faaij et al, (2004).

[23] Sustainable Wood Biomass Management in Central and Eastern European countries; (meeting organized November 9 – 11, 2005 in Bled, Slovenia with support from the Slovenian Ministry of Agriculture, Forestry and Food and FAO(http/www.zgs.gov.si/fileadmin/zgs/main/img/CE/biomasa/BIOMASA_ANG_PROJEKTI/Conclusions).

[24] Third Annual Eastern Biofuels Conference & Expo, Prague, Czech Republic, May 29 – 31, 2007-06-07· (http:www.biomatnet.org/secure/Fair/S831.htm

[25] EU Commission (2005).

[26] EU Commission (2005).

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In Memory of Dr Edgar DaSilva

Lucy Hoareau*

It was with shock and sadness that we learned of the sudden death of our former colleague and friend, Dr Edgar DaSilva. A man of great conviction and energy, Dr DaSilva joined UNESCO in 1974 and worked for many years in the basic sciences at UNESCO. He held the position of Director of the Division of Life Sciences at the time of his retirement. He was a man to be admired for his integrity, determination, fortitude, his work ethics, vision and actions; in many ways he epitomized the spirit of the United Nations.

His foresight and perception of science in the global context, allowed him to be proactive in identifying scientific priorities and developing new and appropriate thrusts for UNESCO programmes. Through his extraordinary commitment, he made a considerable contribution to the development of the Organization's programme in applied microbiology and biotechnology.

He was instrumental in the initiation of the UNESCO Microbiological Resource Centers (MIRCEN) programme, which he co-founded. This worldwide network which became synonymous with Dr DaSilva, had as its objectives the conservation, management and use of microbial gene pools, and to carry out research and development in microbiology and biotechnology. Altogether 34 MIRCEN centres were established worldwide. He also played a major role in the establishment of the UNESCO Biotechnology Action Council (BAC) programme and within the framework of this programme, he was the driving force behind creation of the Biotechnology Education and Training Centres (BETCEN) concept and the implementation of the 5 BETCENs, one in each region. Through these two programmes he made a considerable contribution to development of biotechnology research and training worldwide. The MIRCENs and BETCENs proved to be very successful in

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providing opportunities for training in various areas of biotechnology. This success was in no small part due to Dr DaSilva's continued interest and effort to support their actions. He was devoted to his work and his accomplishments in promoting the activity of these two programmes is evident by recognition of his work in the international scientific arena.

Dr DaSilva was a great proponent of building capacity in the developing and least developed countries and in providing them with the tools for their continued development. He worked tirelessly to ensure that UNESCO's programmes in the life sciences and in biotechnology appropriately benefited those countries that needed them most. His unfailing support and encouragement for these activities allowed young scientists from many developing countries to acquire new knowledge and technical skills which otherwise would have been denied to them.

He strongly believed in collaboration as a means to address the issues and needs of developing countries, stimulate development and provide them with the tools to drive their own scientific research. He created opportunities, identified international partners who shared his vision and enthusiasm to make things happen.

Dr DaSilva made a major contribution to world microbiology and biotechnology. He tirelessly pursued these goals believing that microbiology and biotechnology could offer much to developing countries to help them develop their own unique resources and make a lasting impact on microbiology throughout the world. Very early in his career at UNESCO, Dr DaSilva recognized the value of microbial resources. He mobilized several extrabudgetary programmes in close cooperation with UNEP and UNDP and Donor Member States for activities in national development in biotechnology and regional cooperation in microbiology. This largely resulted in the development of several of the MIRCEN centres.

He supported programmes that provided opportunities for international cooperation, for example the International Training Programme at the German Research Center for Biotechnology (GBF), now the Helmholtz Centre for Infection Research (HZI), which for many years (1987 – 2000) ran intensive 6-7 week training programmes for biotechnologists from developing countries. For many participants this provided important experience towards their career development. Dr DaSilva served on the Board of Advisors for this programme.

With the American Society for Microbiology (ASM), office of International Affairs and the International Society for Microbiological Societies (IUMS), among others, he developed programmes for capacity-building through fellowship schemes and support for collaborative research. He worked with numerous other organizations like the International Cell Research Organization (ICRO) and the International Organisation of Biotechnology and Bioengineering (IOBB), to develop courses and training activities, also playing an important role in the conferences on the 'Global Impact of Applied Microbiology' (GIAM), among many others.

He built strong links with the World Federation for Culture Collections (WFCC) and the International Congresses for Culture Collections (ICCC), encouraging and supporting the organization of training courses. These activities had a strong influence on the development of culture collections and were instrumental in making the WFCC and the MIRCENs recognized as international organizations of culture collections and biotechnology. Dr. DaSilva was elected as Vice President of the WFCC in 1973 and served until 1976.

Dr DaSilva was in every way dedicated to his professional mission and, even after retirement from UNESCO, continued to lecture in institutions in Japan, the Republic of South Africa, the Nordic countries, and elsewhere.

He strongly believed that advances in scientific knowledge and information should be accessible to all and that endogenous research should be given the necessary support and recognition. To this end he actively followed through with action to develop the *MIRCEN Journal of Applied Microbiology and Biotechnology*. This was launched in 1985 and Dr DaSilva was the initial Chairman of the Editorial Advisory Board. The venture was backed by UNESCO and publication was undertaken by Oxford University Press. In 1990 the Journal, after having proved a great success was re-vamped and re-launched with a more encompassing title: *World Journal of Microbiology and Biotechnology* (WJAMB) and served as a platform to give voice to researchers from developing countries. Here again Dr DaSilva's input into the Journal was considerable. He instigated several special issues of the Journal that covered a variety of key topics but all of which focussed on some unique aspect of microbiology being carried out in developing countries which was of significance and relevance to the rest of the world. Dr DaSilva remained an Editorial Advisor for the Journal, to the end.

He supported the Electronic Journal of Biotechnology based at the Universidad Catolica de Valparaiso, Chile, and became a member of its editorial board. He worked with them to create a section Biotechnology Issues for Developing Countries and with UNESCO support, ensured that this journal was made available to institutions in developing countries in CD format. His support, enthusiasm and commitment were decisive for the achievements of this journal. Likewise with the Research and Information System for Developing Countries (RIS), in India, through UNESCO's programmes, he provided support for production of the *Asian Biotechnology and Development Review* (ABDR), and its dissemination to MIRCEN centres in developing countries. He served on the Editorial Advisory Board of this Journal. He also initiated collaboration with the ASM, providing support through the UNESCO MIRCEN programme, for their Global Outreach Programme, thereby providing free access to institutions and researchers in the least developed countries, to Microbe Library and the 12 peer reviewed ASM journals in microbiology.

Dr DaSilva contributed steadily, to scientific literature during his career and wrote numerous articles and reviews for several journals, more specifically those concerned with the fields of microbiology and biotechnology. He continued to publish articles well into his retirement. More recently he served as co-theme editor of theme "Biotechnology" for the UNESCO-sponsored Encyclopaedia for Life Support Systems [EOLSS].

Dr DaSilva was to many a friend and mentor, and a leader with a passion for the development of science in the developing world. He will always be remembered by his colleagues and the scientific community for his dynamism, his competence and dedication. Countless individuals and institutions, especially in the developing world, will remember him for the opportunities he opened up for them.

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1. Articles should be submitted in duplicate to the Managing Editor, Research and Information System for Developing Countries (RIS), India Habitat Centre, Zone IV-B, Lodhi Road, New Delhi 110003, India (Tel. 00-91-11-24682177-2180, Fax: 00-91-11-24682173/2174, E-mail: sachin@ris.org.in) Manuscripts should be accompanied by a floppy disc in IBM compatible format, preferably in MS Word, identical in every respect to the hard copy typed on A4—paper on one side only, double-spaced throughout and with ample marging on all four sides.
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4. Use figures (rather than world) for quantities and exact measurements including percentages (2 per cent, 3 km, 36 years old). In general descriptions, numbers below 10 should be spelt out in words. Use thousands, millions, billions, not lakhs and crores. Use fuller forms for numbers and dates— e.g., 1980-88, pp. 200-202 and pp. 178-84.
5. Specific dates should be cited in the form June 2, 2004. Decades may be referred to as 'the eighties'. Spell out 'the twentieth century', etc.

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All references should be embedded in the text in the anthropological style – for example '(Hirschman 1961)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary only if the cited portion is a direct quote)

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More than one reference of the same date for one author should be cited as 'Shand 1999a, 1999b'.

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Amsterdam: Free University.

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Special Issue on Access and Benefit Sharing

Guest Editor: **Balakrishna Pisupati**

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Access and Benefit Sharing (ABS): Issues and Policy Options

Introduction

Balakrishna Pisupati*

There cannot be a more decisive moment for the conservation community, economists and social scientists to focus on issues of ethics and equity with respect to genetic resources than now. Be it the ongoing debates on the need to reward local communities for their conservation action or the raging challenges of food insecurity, access to resources and sharing the benefits of such access and subsequent use is the core of international environmental governance debate.

Though the issue of access and benefit sharing (ABS) under the Convention on Biological Diversity (CBD) has received attention during the past one and half decades, it still remains a technically challenging and legally complex issue. One clear problem with ABS debates has been the limited experience of dealing with the issues at national level and implementation of ABS provisions. Most of the discussions still continue to focus on political positions and advocacy in spite of us having the Bonn Guidelines on ABS adopted by Parties to CBD as early as 2002. Lack of implementation of Bonn Guidelines is clearly a missed opportunity.

Having been following the discussions under ABS for a long time, it is very interesting to see how various developments under these discussions have contributed to today's status. Beginning with the need to develop national regimes on ABS, the need to address issues of business and commerce in ABS, the importance of addressing ABS from ecosystem perspectives – especially the one on marine genetic resources, the role of clear understanding of tools such as certificates of origin, the need to include gender into ABS debates, the emerging discussions on role of regional trade on ABS and more recently the need to learn from other such similar processes (such as the one under the International Treaty on Plant Genetic Resources for Food and Agriculture) have all provided the much needed fuel to keep the engines of ABS discussions running.

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The views expressed by the guest editor are his personal views and opinions and not that of the organization he represents.

What has been attempted in this special issue of Asian Biotechnology and Development Review is an attempt to capture the above debates from the expert's point of view. We are very fortunate to have such an assembly of experts coming forward to contributing their thinking into ABS dialogues and more so to mainstream them into debates ranging from biotechnology to development. Particular thanks are due to the co-chairs of the CBD ABS Working Group on ABS who contributed a think-piece on how they see the process progressing.

What we need now a global commitment to make ABS work and not just intentions of supporting the process. While we all agree that ABS is a complex and complicated issue, complexity should not be a cause for inaction! Let us hope that collective wisdom will prevail to move forward the negotiations of the international regime towards the target date of completing the negotiations by 2010 as agreed by the Ministers of Environment from countries who are Parties to CBD in Curitiba during COP 8.

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The Question of Minimum Standards of Access and Benefit-sharing under the CBD International Regime: Lessons from the International Treaty on Plant Genetic Resources for Food and Agriculture[1]

Claudio Chiarolla*

Abstract: With the international regime on ABS currently under negotiations to fulfil the third objective of the Convention on Biological Diversity (CBD), this article considers the possible relationship between the emerging international regime and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), especially its benefit-sharing components, paying special attention on the lessons learned from the implementation of the ITPGRFA. In particular, it assesses whether some lessons learned from the ITPGRFA Multilateral System's implementation (MLS) may advance discussions on related international cross-sectoral issues in genetic resources. These issues include the question of whether an International Regime on ABS should expressly provide for international standards, such as mandatory minimum standards for access to genetic resources and benefit sharing in material transfer agreements (MTAs).

Keywords: International Regime; Access and Benefit Sharing; International Treaty on Plant Genetic Resources for Food and Agriculture.

Background

The Earth Summit, held in Rio de Janeiro in 1992, gave rise to three key multilateral environmental agreements. One of these binding agreements is the Convention on Biological Diversity, which was ready for signature on June 5, 1992 and went into effect on December 29, 1993. With its 193 Parties as of 2008, the CBD seeks to establish a comprehensive international programme for the sustainable management of biological resources.[2] It covers all types of biological diversity except for human genetic material.[3] The Convention's three main objectives, which are stated in Article 1, are:

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the conservation of biological diversity; the sustainable use of its components;[4] and the fair and equitable sharing of the benefits arising from the use of genetic resources.[5]

During the negotiations of the CBD, developing countries with a rich endowment in natural resources and crop diversity bargained with developed countries offering access to their genetic resources in return for "debt relief, royalties, technology transfers and research data".[6] However, the implementation of CBD's third objective has proven to be particularly problematic.[7] In 2002, the perceived failure of the so called "grand bargain"[8] and, in particular, poorly regulated access, lack of fair and equitable benefit sharing, and claims of misappropriation of genetic resources were all factors, which contributed to the UN World Summit on Sustainable Development (WSSD) call for action to "negotiate within the framework of the CBD, bearing in mind the Bonn Guidelines, an international regime to promote and safeguard the fair and equitable sharing of benefits arising out of the utilization of genetic resources."[9] Following the call, the Conference of the Parties (COP) of the CBD at its seventh meeting in 2004 decided to mandate the Working Group on ABS, with collaboration of the Working Group on 8(j), to negotiate an international regime on access and benefit-sharing with the aim of adopting an instrument/instruments to implement the provisions in Articles 15 and 8(j) and the three objectives of the Convention.[10]

Benefit Sharing Principles under the CBD and the FAO-ITPGRFA

Article 15 of the CBD regulates access to genetic resources by, *inter alia*: reaffirming the sovereign rights of States to their natural resources; stipulating that Parties shall endeavour to facilitate access to genetic resources; providing that access shall be subject to prior informed consent (PIC) and granted on mutually agreed terms (MAT); and requesting Parties to take measures to share benefits from the utilization of genetic resources, on MAT.

Eager to participate in the sharing of benefits arising from the use of genetic resources and associated traditional knowledge (TK), biodiversity-rich countries have started the development of national and regional ABS regimes. Although their implementation does not appear to have generated the expected benefits so far,[11] such laws were perceived as a factor contributing to freeze long-running cross-boundary movements of plant genetic resources with potential negative consequences on agriculture and food security.[12] This is because the CBD promotes the development of a regime of contractual rules for the exchange of biological resources, which is based on bilateral contracts.[13] However, these bilateral contacts may not be appropriate for crop research for two main reasons: first, countries are enormously interdependent in terms of plant genetic diversity, and second, a very high number of breeding materials is necessary to breed a new plant variety. Thus, in many cases, transaction costs associated with bilateral negotiations for access to the crop biodiversity – and related intellectual property rights over the material, if any – from numerous different sources may be sufficient to discourage plant breeding efforts.[14]

The CBD also addresses *ex-situ* conservation, which is referred to in Article 9 as "the conservation of components of biological diversity outside their natural habitats." Under this provision Parties are encouraged to acquire, conserve, store and manage materials in national and international *ex-situ* collections. However, since the CBD only applies to genetic resources that are provided from *in-situ* conditions or have been acquired in accordance with it, international *ex-situ* collections formed before its entry into force are not governed by the Convention. As early as in 1989, the legal uncertainty regarding the status of these collections triggered the development of the International Network of *ex-situ* collections under the auspices of FAO. Before the adoption of the FAO International Treaty on Plant genetic Resources for Food and Agriculture (ITPGRFA), the bulk of materials held by this network, which comprises the International Agricultural Research Centers (IARCs) of the Consultative Group on International Agricultural Research (CGIAR), were managed in accordance with a non-legally binding instrument called International Undertaking on Plant Genetic Resources (IUPGR) as well as the *in trust* Agreement between the CGIAR Centers and FAO. In November 1994, following a request from the CBD, the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) started negotiations to bring the IUPGR in conformity with the CBD and, in particular, its ABS provisions.[16] However, further developments under the IUPGR, that led to the adoption of the ITPGRFA, were delinked from the CBD discussions for various reasons.

The International Treaty on Plant Genetic Resources for Food and Agriculture not only is the remarkable outcome of this negotiating process, but also responds to concerns arising in connection with the application of bilateral access rules to crop biodiversity.[17] Part IV of the ITPGRFA establishes a Multilateral System of Access and Benefit Sharing through which its Contracting Parties have decided to facilitate access to the 64 most important crops and forages to ensure worldwide food security.[18] Such resources are listed in Annex I of the ITPGRFA.[19]

In June 2006, the Governing Body of the ITPGRFA at its fist session established the level, form and manner of equitable benefit sharing payments to be implemented through a standard contract called Standard Material Transfer Agreement (SMTA). The SMTA does not require a burdensome mechanism to track individual accessions, while it ensures that benefits flow back to the Multilateral System (MLS) if a product based on MLS materials is commercialised. In particular, a continue chain of SMTAs between providers and recipients ensures that the benefit sharing obligations of the ITPGRFA are passed onto any "person or entity" that develops a product (*i.e.* seeds) derived from the Multilateral System.[20] Under the ITPGRFA and the SMTA, benefit sharing includes monetary (Article 6.7) as well as non-monetary benefits (Article 6.9)[21] and voluntary contributions (Article 6.8 and Article 6.11). If certain legal requirements are met, compulsory benefit sharing payments of 1.1 per cent of the gross income from the sale of seeds (minus 30 per cent to allow for sale costs) must be paid by recipients to the Multilateral System.[22] In particular, the commercialised product (*i.e.* the seeds whose sale is relevant for the benefit sharing provision of the SMTA) must: (a) incorporate the material received from the MLS and (b) shall not be freely available for further research and breeding, because of patent protection or otherwise. Beyond the physical incorporation of the material into a new product, in cases where no physical transfer of material is involved, the link established in Article 6.10 of the SMTA between the assignment of relevant IPRs and the transfer of recipients' benefit sharing obligations to the assignee suggests that "the incorporation into a proprietary product of patented information, which results from research and development carried out on MLS materials, may give rise to benefit sharing payments *per se*".[23]

Apart from its many technicalities, the Multilateral System, which is implemented through the use standard contracts, presents numerous and considerable advantages for agricultural research: (i) the SMTA reduces transaction costs, because it does not require *ad hoc* negotiations between providers and recipients of PGRFA; (ii) it provides some scope for flexibility in handling derivatives, which are "under development," and in particular, it allows for additional conditions to be attached to their transfer (Articles 6.5 and 6.6); and, (iii) in the case of non-compliance by recipients with the SMTA, it provides for binding international arbitration (Article 8.4(c)) and confers upon FAO, on behalf of the Governing Body, third party beneficiary's rights to represent the interests of the Multilateral System.

The particular importance of the ITPGRFA for the international ABS regime negotiations under the CBD stems from two main facts. First, to date the ITPGRFA is the only legally-binding international instrument that implements the ABS principles of the CBD. However, its ABS provisions only apply to a subset of plant genetic resources relevant for food security and sustainable agriculture, which are defined in accordance with a number of cumulative criteria. Such criteria are determined as follows: (i) the PGRFA concerned must be expressly included in the list, which is annexed to the ITPGRFA; (ii) they must be used in breeding, research and training food and agriculture; and (iii) they shall not be encumbered by third parties' rights and other interests, in the sense that they should be under the management and control of Contracting Parties and in the public domain. Second, because of the above, any new instrument or instruments, which might be developed with the view to being adopted by CBD Parties, may need to cover all the benefit sharing instances not expressly regulated by the ITPGRFA, while not precluding the potential expansion of the latter, in particular, with respect to crops not yet included into its Multilateral System of ABS.

Finally, "the important contribution" of the ITPGRFA and its continuing relevance for the negotiation of the International Regime on ABS is emphasised in COP Decision VII/19D, which refers to it both in its preambular language – where the ITPGRFA is the only treaty to be mentioned apart from the CBD – and in the list of elements, which shall be considered for inclusion in the international regime.[24]

Recent Developments relevant for the International ABS Regime Negotiations

The negotiation of an International Regime on Access and Benefit Sharing under the Convention on Biological Diversity made some progress so far during the fifth and sixth meetings of the *Ad Hoc* Open-ended Working Group on Access and Benefit Sharing (ABS), which were held respectively in Montreal, October 8-12, 2007, and in Geneva, January 21-25, 2008.[25] In particular, the sixth ABS meeting marked a considerable step forward thanks to an innovative approach for consensus building. Actually, the contact group temporarily agreed to set aside negotiations on contentious issues concerning the nature and scope of the international regime and engaged in constructive discussions on its main components.[26]

The main result of this approach is that "for the first time since the launching of the process, no Party questioned the general need for an international regime," allowing to move forward into substantive discussions and text-based negotiations.[27] As a consequence, the official outcome document, which was adopted by the Working Group, is a solid basis for future negotiations.[28] Such negotiations must be concluded "at the earliest possible time before the tenth meeting of the Conference of the Parties."[29] During the upcoming ninth meeting of the COP to be held in Bonn, Germany, in May 19-30, 2008, time might not allow the Parties to advance discussions on substantive items of the international ABS regime-related agenda. However, this meeting will be crucial to decide important process-related issues, including the number of ABS Working Group meetings prior to COP 10 and funding.[30]

Work in Progress: The International Regime on ABS

The draft "Recommendation on Possible Elements of a Decision on Access and Benefit Sharing" for consideration of COP 9 is basically the outline of the international regime's structure and is divided into four main parts, namely: "Objective," "Scope," "Main Components," and "Nature" of the International Regime.[31] Without giving prejudice to the eventual nature of the international regime or any of its elements, being this paper confronted with the task of identifying potential lessons from the implementation of the ITPGRFA, it wonders what specific elements of the FAO Multilateral System and the SMTA can provide a basis for furthering the ABS discussions under the CBD. Because of the legally binding nature of the ITPGRFA, the following discussion is based on the assumption that relevant comparable elements of the international ABS regime could be accomplished in a legally binding setting. This assumption is necessary merely to facilitate the comparative analysis that follows, hoping that it might be acceptable to the reader in the light of the above disclaimer. Rather than dismissing the possibility to discuss binding elements, which might be controversial, an attempt is made to identify the reasons why stumbling blocks could emerge, which might impede to extend solutions that appear to work in the context of the ITPGRFA.

Lessons Learned from the ITPGRFA

An information document prepared for COP 9[32] considers the role of IPRs in technology transfer in the context of the CBD and underlines "the importance of specific bilateral arrangements, in particular ...material transfer agreements or bio-prospecting agreements, in defining each party's rights, interests and obligations." Then, it continues, "Without giving prejudice to the appropriateness and suitability of a wholly bilateral approach ...and, conversely, to the need for overarching principles and legal obligations that would provide a surer safeguard for the equity and legitimacy of specific arrangements ...the design of such arrangements seems to be an important factor for ensuring that they operate to generate new technologies and new benefits, shares those benefits equitably, and respects the interests and concerns of the resource providers."

On these premises, the role of the Standard Material Transfer Agreement (*i.e.* the specific bilateral arrangement, which implements the benefit sharing provisions of the ITPGRFA) and "the way it can be used to keep track of transfers of materials and to link their use to benefit-sharing is a very useful precedent" for the ABS Working Group to consider (SGRP, 2007: p. 3). In particular, the CGIAR Centres (2007: p. 3) suggest that "the SMTA functions as a certificate of source, with the source or origin of the PGRFA being the MLS itself." Thus, the SMTA functions not only as a certificate of source or compliance with the ITPGRFA, but also as an essential mechanism for its implementation.

The key question is whether an International Regime on ABS should expressly provide for international standards, such as mandatory minimum standard terms for access to genetic resources and benefit sharing in material transfer agreements (MTAs) and the issue of how to define and manage derivatives and their products thereof, as well as potential impacts of such international regulatory mechanisms on the overarching objectives of the Convention. Some may observe that the practical possibility to introduce into the International Regime on ABS a set of multilaterally agreed standards to be implemented though the use of private contracts, in the wake of the model adopted by the ITPGRFA, depends on the willingness of Parties to accept a bargain along the following lines. This bargain is likely to present a trade-off between the inclusion of international standards on access to genetic resources, which appears to be on top of the user countries' agenda and a range of other important issues, such as: an international definition of misappropriation; some minimum standards to deal with benefit sharing; the issue of derivatives; and an appropriate mechanism to encourage, monitor and enforce compliance with national ABS legislation, including though an "internationally recognized certificate of origin/source/legal provenance."

As regards compliance, at least one study has specifically considered the implications of ABS monitoring and enforcement through the use of private contracts, including private international law aspects that concern the applicable law to the SMTA in the context of dispute settlement.[33] In addition, a dedicated Expert Group has discussed in detail the options for a certificate of origin.[34] Therefore, the concluding part of this paper focuses on the ABS-related terms in the SMTA that regulate the issue of derivatives and it wonders how these terms can be useful for international ABS regime development under the CBD.

Derivatives and misappropriation are terms, which are not expressly defined either in the ITPGRFA or in the SMTA. Before the adoption of the SMTA, Fowler *et al.* (2004: pp. 663-4) "sought to bring clarity to these issues by proposing how the 'germplasm and related information' covered by the FAO-CGIAR Agreements should be interpreted and by describing a number of options for minimum requirements for taking out intellectual property protection on derivatives and components of designated germplasm." However, the authors note, "the FAO, the CGIAR and the international community ...may choose to retain the *status quo* in which the question of what can and cannot be done with designated germplasm is left unanswered. Choosing not to deal with the subject is itself a choice, though perhaps not the best one."

Because it creates legal uncertainty, the SMTA built-in 'constructive ambiguity' or 'strategic vagueness' concerning the extent to which IPRs should be allowed to cover materials derived from the Multilateral System is not desirable. The same argument may possibly apply to the forthcoming ABS regulation under the CBD International Regime. However, in the context of the ITPGRFA, the above was a compromise necessary to build consensus on other aspects of the SMTA on which such consensus could be reached. More importantly, the absence of an express definition of derivatives does not impinge upon the clear-cut legal identification of derivative products for the purpose of benefit sharing, including mandatory payments. The incorporation requirement both in the definition of "Product" and in Article 6.7 of the SMTA does not leave scope for doubts regarding the fact that any product, whose commercialisation may trigger benefit sharing payments, must qualify as a derivative in the strict sense that it must contain the material received from the Multilateral System – or its genetic parts or components. In addition, the SMTA makes no reference to any particular percentage of MLS material to be incorporated into the final plant variety; therefore, there are no minimum levels of incorporation to define derivative products for benefit sharing purposes. This is the balance struck in the SMTA.

In the context of international ABS regime discussions, the critical question revolves around the issue of whether the incorporation requirement used in the ITPGRFA could be successfully employed to identify derivative products for the same benefit sharing purposes discussed above. Unfortunately, the direct application of the incorporation requirement into a context other than plant breeding may prove difficult. This is because the creation of new plant varieties inherently reduces to an activity, which makes use of multiple genetic parts and components that contain "functional units of heredity." On the contrary, many gene products at the sub-organisms level, non-DNA molecules and proteins do not contain such "functional units of heredity;" therefore, they may fall outside of the system. This might be the case, for instance, of natural product discovery in the pharmaceutical sector. Thus, the incorporation requirement might need some further qualification to comprise categories of products, which are based on genetic resources, because product discovery would not occur without their use, although the genetic information is not eventually contained in the product. In these respect, it might be useful to further elaborate the relationship between biological resources and genetic resources as functional elements[35], which may comprise both "the tangible biological material ('micro-tangibles') and the intangible asset (the genetic information)."

Turning the attention to the concept of misappropriation, under the ITPGRFA any use of MLS materials would qualify as misappropriation, if it violates the conditions established in the SMTA, including any illegal transfer of the original material and its derivatives – which may be either "Products" or "PGRFA under development"– as well as derivative intellectual property rights. The report of the Expert Group on an internationally recognised certificate (2007: par. 26 and 41) has also emphasised that: "transfers to third parties should require maintenance of the link with the certificate and the mutually agreed terms applying to the resources." It has also noted that "additional implementation challenges and costs may be related to the coexistence of genetic resources inside and outside the system." Therefore, the complementarity between the SMTA and a certificate of compliance under the CBD International Regime is a factor, which may contribute to reduce costs from materials being exchanged outside the system.

Finally, as to the issue of establishing minimum benefit sharing conditions, monetary payments of 1.1 per cent of the gross sale of any derivative products, in accordance with the ITPGRFA, should be taken as the baseline for minimum standard payments for access to genetic resources covered within the scope of the International Regime. The above percentage was agreed by the Parties of the ITPGRFA having in mind both the nature of plant breeding, which is less capital intensive than other research and development (R&D) activities in biotechnology, and the relatively low value of each potential contribution of a PGRFA to the final product; therefore, such percentage should be acceptable as a minimum standards for other biotechnology sectors in which the use of genetic resources may have more promising applications in terms of economic returns from R&D.

A Note of Caution

Rose (2003: p. 362) provocatively questions whether "the paper used over seven years of negotiations," which were necessary to develop the ITPGRFA, was "worth the trees." Koester (2002: p. 103) responds that "when faced with the question 'have we really accomplished anything?', the only answer is: what would be the condition of our biodiversity if these conventions did not exist?" He makes an important point indeed, which is valid also in the context of the international ABS regime negotiations.

In Rose's opinion, "the answer is yes," it was worth, because the ITPGRFA "will operate to ensure availability of PGRFA, simplify transfers, promote fairness in benefit sharing, and direct some benefits towards PGRFA conservation." If all the above is being accomplished thanks to multilateral cooperation on biodiversity conservation, that is indeed a great success. However, to the extent that the ITPGRFA sets global rules, which impact on scientific research and plant breeding, the former can be considered a success story only because the affected scientific community eventually endorsed the proposed solutions – or at least could leave with them.[36]

In the same vein, it will be necessary to carefully ensure that the regulation that is being proposed under an International Regime on Access and Benefit Sharing gives due consideration to the practical way in which trans-national collaboration actually takes place in the research community (see, for example, Jayaraman, 2008). At this point of negotiations, one of the risks that all ABS policymakers should be taking care of is that "legislation and practice that seeks to implement the CBD do not unduly restrict the legitimate use of genetic resources, discouraging scientific research." (UK Commission on Intellectual Property Rights, 2002: Chapter 4). In this respect, it might be appropriate to increase efforts to distinguish between commercial and non-commercial research, and to set facilitated standard access conditions for those who do not seek access for commercial purposes.[37] However, if the potential for developing a commercial product exists, the ABS International Regime should not prevent genetic resources, which have been acquired in accordance with non-commercial terms, from being used in a commercial research programme. This may occur under a new set of mutually agreed terms that reflect a different balance of benefit sharing obligations. Therefore, a chain of MTAs would be necessary to maintain the link between the provider and any subsequent recipient of genetic resources and their derivatives. This mechanism could be essentially based on the development cycle model used within the FAO Multilateral System.[38]

Endnotes

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[2] Glowka et al. (1994); Koester (2002).

[3] Biodiversity is the variability among living organisms. This covers: (a) genetic resources, (b) the portfolio of animal and agricultural species developed throughout the world and (c) the diversity of ecosystems.

[4] Article 2 of the CBD defines the term "sustainable use" as the use of components of biological diversity in a way that does not lead to its long-term decline and that meets the needs of present and future generations.

[5] "Genetic resources" are defined as genetic material of actual or potential value that contains functional units of heredity.

[6] Blakeney, 2002: 27-9; see also Chandler (1993).

[7] UNU-IAS (2003), p. 14, reports that only 50 countries either have "adopted or are in the process of adopting measures to exercise and secure their sovereign rights over genetic resources." See also: Chambers (2003) at p. 316.

[8] Siegele (2008).

[9] Paragraph 44(o) of the Johannesburg Plan of Implementation.

[10] Paragraph 1 of CBD COP Decision VII/19D; previous key developments on ABS policy-making under the Convention on Biological Diversity include, inter alia: a decision by the Conference of the Parties at its fourth meeting (COP IV) establishing an expert group on ABS in 1998; a decision by COP V establishing the Open-ended Working Group on ABS in 2000; the adoption of the Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of Benefits Arising out of their Utilization at COP VI in 2002. The above list, however, is not exhaustive; for a complete overview and analysis of recent developments leading to the international ABS Regime negotiations see: Hodges and Daniel (2005), and IISD (2008).

[11] IUCN (2006) reports: "Since 1993, considerable, although still insufficient, progress has been made in implementing CBD obligations and principles especially through national laws and obligations. However, the effectiveness of national and regional measures has proven to be limited resulting in WSSD's call for an international framework."

[12] Managers of CGIAR Centres frequently attributes the significant decline in the rate of acquisition of new materials by most of Centres' genebanks in recent years "to the highly politicised nature of access and benefit sharing issues at international, national and regional levels." See: Halewood and Sood (2006)

[13] Queen Mary Intellectual Property Research Institute et al. (2000), pp. 54-74. The conventional access agreements thus developed are called Material Transfer Agreements (MTAs).

[14] Chiarolla (2006).

[15] The text of the IUPGR, which was adopted in 1983 by Resolution 8/83 of the FAO Conference, is available at: http://www.fao.org/ag/cgrfa/IU.htm. In 1983, given the global interdependency of all countries in terms of crop diversity, FAO Countries endorsed the creation of the FAO Global System for the Conservation and Utilization of Plant Genetic Resources for Food and Agriculture. The Global System is composed by several tools, which include specialized international bodies and agreements, plant germplasm collections, scientific networks and an early warning system. Further information is available at: http://www.fao.org/FOCUS/E/96/06/06-e.htm. The component of the Global System that provided the formal

framework for international action to promote the conservation, sustainable use and availability of crop biodiversity was the IUPGR. In particular, Article 5 of the IUPGR recognised the principle of unrestricted access to plant genetic resources in the following terms: "It will be the policy of adhering Governments and Institutions having plant genetic resources under their control to allow access to sample of such resources, and to permit their export, where the resources have been requested for the purposes of scientific research, plant breeding or genetic resources conservation. The sample will be made available free of charge on the basis of mutual exchange or on mutually agreed terms." See also Andersen (2005).

[16] In 1992, the Conference of the Parties of the CBD recognised that the regime developed under the Convention on Biological Diversity was not well suited to PGRFA and handed this issue over to the FAO. See Resolution No. 3 of the Nairobi Final Act.

[17] The Treaty was adopted by the FAO Conference on November 3, 2001. It entered into force on June 29, 2004 and has 116 Parties (information updated until March 2008). See in general: Moore and Tymowski (2005).

[18] Bellon (2006).

[19] While the ITPGRFA encourages facilitating access to all plant genetic resources for food and agriculture, only PGRFA which are under "the management and control of the Contracting Parties and in the public domain" will be automatically included into the MLS (Article 11.2). However, such resources must be used only for the purpose of utilisation and conservation for research, breeding and training for food and agriculture, being other uses, such as chemical, pharmaceutical and/or other non-food/feed uses regulated in accordance with the CBD.

[20] Article 12.4 of the ITPGRFA states: "the recipient of PGRFA shall require that the conditions of the MTA shall apply to the transfer of PGRFA to another person or entity, as well as to any subsequent transfer of those PGRFA."

[21] Visser et al. (2005).

[22] Article 6.7 of the SMTA states: "In the case that the Recipient commercializes a Product that is a Plant Genetic Resource for Food and Agriculture and that incorporates Material as referred to in Article 3 of this Agreement, and where such Product is not available without restriction to others for further research and breeding, the Recipient shall pay 1.1% (less 30%, to allow for sales costs) of the Sales of the commercialized Product."

[23] Chiarolla (2008: p. 4).

[24] See, in particular, the Annex to Decision VII/19D(d)(xxii) under "relevant elements of existing instruments and processes."

[25] The terms of reference for the ABS Working Group are contained in the Annex to Decision VII/19D, which sets out a number of agreed parameters for the negotiation. These parameters concern, in particular: (a) the process, which shall be based on a gap analysis; (b) the nature of the international regime, which revolves around the questions of whether the latter should include one or more instruments and whether it should be legally-binding or not; (c) its scope, which includes access to genetic resources and sharing of benefits, as well as traditional knowledge; and (d) a list of elements, which shall be considered for inclusion in the regime, comprising references to relevant existing instruments and processes. See: Scott (2007).

[26] Such components are listed in the Annex to Decision VII/19D, including inter alia: measures to ensure benefit-sharing (i), (ii), (iii), (v), (vi), (xiii), (xiv); measure to facilitate access (iv); measures to ensure compliance with PIC and MAT (ix), (x), (xi); protection of traditional knowledge (xv), (xvi), (xviii); compliance mechanisms (xx), (xxi); measures to facilitate implementation of the regime (viii), (xix), (xxii); relevant elements of existing instruments and processes (xxiii); and others.

[27] IISD (2008: p. 10).

[28] CBD (2008a: and Annex, pp.11-20).

[29] This deadline is established in CBD COP Decision VIII/4A, par. 6. In addition to renewing the mandate of the Working Group (WG) and setting the above timeframe for the negotiation, this Decision, in section C, established a Group of Technical Experts on an internationally recognised certificate of origin/source/legal provenance, which meet in Lima, Peru, in January 22- 25, 2007. See: CBD (2007). The Group of Technical Experts considered the possible rationale, objectives and the need for an internationally recognised certificate of origin/source/legal provenance; defined the potential characteristics and features of such an internationally recognised certificate; analysed the distinction between the options of certificate of origin/source/legal provenance and implications for achieving the objectives of Article 15 and 8(j); and identified associated implementation challenges.

[30] CBD (2008b: Item 4.1. par. 79).

[31] CBD (2008a).

[32] CBD (2008c: par. 189).

[33] Chiarolla (2008).

[34] CBD (2007).

[35] Tvedt and Young (2007: p. 63-5).

[36] The CGIAR Centers report that over the first eight months of 2007 "a total of 97,669 samples were distributed under the SMTA" and "only three potential recipients have refused explicitly to accept materials under the SMTA." See: FAO (2007), par. 7-8.

[37] As regards the question of how to draw the line between commercial and non-commercial research, this paper has noted that within the FAO Multilateral System monetary benefits must be shared, if an IPR restriction limits the facilitated access to a derivative research product. Thus, in general, users' applications for IPR protection are a useful element to distinguish between commercial and non-commercial research, because they are a clear indication of the intention to develop and commercialise a product to be sold on the market, including in the form of licensing.

[38] Chiarolla (2008).

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Free Trade Agreements and Access to Genetic Resources and Benefit Sharing: Exploring the Linkages[1]

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Abstract: This article highlights the potential relationship between Trade in general, and FTAs in particular, and the negotiations on an international regime for access and benefit-sharing within the context of the CBD, and identifies some questions requiring further scrutiny. In particular this article addresses the linkages between Trade (in particular) FTA and ABS in the context of the disclosure of origin of genetic resources in IPR applications and the restrictions on intellectual property rights (IPR) applications for inventions derived from genetic resources for which an access permit was granted and the relationship between ABS and investment and services rules in FTA.

Keywords: Access and benefit sharing; Convention on Biological Diversity; Intellectual Property Rights; Free Trade Agreements; World Trade Organization.

Introduction

A growing number of bilateral and regional free trade agreements (FTAs) incorporate provisions relevant to biodiversity. Meanwhile, there are ongoing negotiations on an international regime governing access to and the equitable sharing of benefits from genetic resources derived from biodiversity under the Convention on Biological Diversity (CBD). While there are clear linkages between the two sets of regimes, scant research has been conducted on the implications – both positive and negative – of the trade and intellectual property provisions included in FTAs on the international regime for access and benefit-sharing (ABS). This article highlights the potential relationship between Trade in general, and Free Trade Agreements (FTAs) in particular, and the negotiations on an international regime for access and benefit-sharing

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within the context of the CBD, and identifies some questions requiring further scrutiny. Despite the theoretical speculations, it is still uncertain if and how FTAs might have an impact on the negotiating dynamics and country positions with regard to the international regime. More time and analysis will thus be needed in order to identify the potential impact of Trade and FTAs on the negotiations and final outcome of an international regime for ABS.

A growing number of bilateral and regional FTAs incorporate provisions relevant to biodiversity as it is explained below. Meanwhile, there are ongoing negotiations on an international regime governing access to and the equitable sharing of benefits from genetic resources derived from biodiversity under the Convention on Biological Diversity (CBD). While there are clear linkages between the two sets of regimes, scant research has been conducted on the implications – both positive and negative – of the trade and intellectual property provisions included in FTAs on the international regime for access and benefit-sharing (ABS) related to biodiversity. Most of the analysis undertaken so far has focused on the issue of disclosure requirements.

Disclosure of Origin and International Trade: Are FTAs Restrictive or Supportive?

Rules governing access and benefit-sharing are linked to intellectual property rules (and trade rules) in several ways, some of these include:

- ABS rules may pose restrictions on intellectual property rights (IPR) applications for inventions derived from genetic resources for which an access permit was granted. For example, the Biodiversity Law of Bhutan requires prior notification, and India's Biodiversity Law requires prior written authorisation.
- ABS-related rules may require the disclosure of the origin of the materials in an IPR application that concerns or makes use of accessed materials in an invention (incorporated in ABS or Biodiversity Laws, for instance in the Andean Pact Decisions 391 and 486; the Costa Rica Biodiversity Law; the Provisional Measure of Brazil).

One of the measures suggested in order to achieve a synergistic relationship between the CBD and intellectual property systems (in particular, the WTO TRIPs) was the disclosure of the origin of genetic resources or associated traditional knowledge in intellectual property right applications, particularly in patents. For several years the CBD, the World Trade Organization (WTO), the World Intellectual Property Organization (WIPO), and other agencies through their reports have insisted on the need to promote disclosure of origin in IPR applications.[2]

The Conferences of the Parties to the Convention have also addressed the relationship between IPR and biodiversity. For example, at the III Conference of the Parties, Decision III/15 (access to genetic resources) requested the Executive Secretary to cooperate with the WTO through its Committee on Trade and Environment in order to explore the extent to which there may be links between Article 15 of the Convention and the TRIPs. Decision III/17 also recognized, among other things, that further research is required in order to understand the relationship between the provisions of the TRIPs and the CBD, particularly those points relating to technology transfer and the conservation and sustainable use of biodiversity, fair and equitable benefit-sharing, protection of traditional knowledge, etc. The IV Conference of the Parties (1999 Bratislava), in addition to reiterating a number of previous calls from past COPs, emphasized the need to ensure consistency in the implementation of the Convention and the TRIPs, in order to increase mutual supportiveness between both regimes and ensure that biodiversity-related concerns receive IPR protection (IV/15). The V Conference of Parties (2000, Kenya), in Decision V/26, requested the WIPO and UPOV to properly take into account the relevant provisions of the Convention in their work, including the impact IPR might have on the conservation and sustainable use of biological diversity and particularly on the value of traditional knowledge. Subsequently, it invited the WTO to bear in mind that the TRIPs and the CBD are mutually related and called for a more in-depth exploration of that mutually supportive relationship. COP Resolution VI/24/C 1, *"The Role of IPR in the Implementation of Benefit-Sharing Agreements"*, invited the governments and Parties to promote disclosure of the origin of genetic resources in intellectual property right applications when the protected material consists of or makes use of genetic resources in its development. The aim of this disclosure is to help track compliance with prior informed consent and the mutually agreed conditions on which access to those resources was granted. Numeral 2 contains the same invitation regarding associated traditional knowledge. At the VII Conference of the Parties, Decision VII/ 19 requested the Working Group on Access and Benefit Sharing (WGABS) to identify aspects related to disclosure of the origin of genetic resources and associated traditional knowledge in IPR applications, including aspects related to the certificate of origin/source/legal provenance. It also asked the WIPO and UNCTAD to prepare studies on disclosure of origin in IPR applications, based on a list of topics that need addressing.

The Bonn Guidelines also refer to this topic when they indicate that user country measures should take into account measures to promote disclosure of the origin of genetic resources and the origin of knowledge, innovations, and practices in intellectual property right applications (16.d.ii).

Main Elements of the Disclosure Proposal

It is not surprising that the requirement for disclosure of origin / proof of legality of access in intellectual property applications should be the object of intense political and legal debate. Although different legislations contain references to this requirement, they differ in terms of their consequences.[3] Some of the biodiversity or intellectual property laws contain the obligation to disclose the origin of genetic material utilised in inventions or plant varieties, or even to present proof of the existence of prior informed consent or a certificate of origin that establishes the legality of access to the genetic material or associated traditional knowledge. This stipulation would help to support compliance with the CBD provisions on access to genetic resources and benefit-sharing.

In most cases, the European laws that have introduced this requirement refer only to the obligation to disclose the origin or, in the case of Norway, to prove the existence of PIC (only for genetic materials, not for traditional knowledge). However, these laws do not affect the existence of intellectual property rights as such, but rather fall within the penal or civil domains. Likewise, few laws on plant breeder rights, especially in India, consider this situation.

As Correa (2005) states, "Although the purpose of this obligation and its rationale seem clear enough, and there is substantial – though not unanimous - support for it to be established, the conditions and circumstances of this obligation and how it will be applied need to be more precisely defined..." The scope and conditions of application of the obligation should be consistent with its purpose, and care should be taken not to impose a disproportionate burden on the applicants and the institutions in charge of their applications".[4]

However, other aspects should be taken into account when considering the inclusion of disclosure of origin in the International Regime negotiations:

(a) The instrument has a limited impact on the prevention of misappropriation or biopiracy, and should, therefore, be accompanied by other complementary mechanisms. For example, in a number of documented cases of misappropriation through patents, the geographical origin of the resource was mentioned. In order to improve the quality of the granting of patents and other intellectual property rights, search systems in order to determine if the inventions are novel are needed. These complementary mechanisms have been explored by the WIPO Intergovernmental Committee on Genetic Resources and Intellectual Property, Traditional Knowledge and Folklore.

(b) Consideration should also be given to whether countries have the ability to effectively monitor patent applications and patents granted in order to determine if there has been misappropriation of materials. Even if misappropriation is detected, it is doubtful that the countries have the economic and financial capacity to invalidate patents in foreign jurisdictions, considering the long and costly process involved. This situation points once again to the need to study other user country measures, for example, those that facilitate access to justice, as required to achieve the objectives of the CBD.

(c) One way to prevent misappropriation is to improve access to information existing in the public domain, and make it available to the technical staff in charge of reviewing patents to aid them in determining if they are novel and if prior art exists. This is one of the aspects the WIPO has been working on through the Intergovernmental Committee.

(d) Finally, although these provisions have been included in some countries' patent laws or in their biodiversity or related laws, it is also advisable, strictly at a national level, for the countries to begin introducing a new statutory obligation into their access or related laws: namely, the requirement for an access applicant to disclose the origin or source of the resource at the time access is granted if the access applicant presents a patent application. Although it is not possible to categorically state whether or how the patent offices will take these legal or contractual provisions into account, or whether they will take action against an applicant that does not comply with them, this measure merits consideration. Incorporating this provision will require that actions be taken at a national level, which should not wait for the conclusion of international negotiations on the Regime or the WTO discussions.

Disclosure and FTA

With regard to free trade agreements, concerns have been raised that in some cases their IP provisions may limit or preclude the opportunities to introduce disclosure of origin requirements. For example, the language used in the US-Central American Free Trade Agreement (CAFTA), states that "Each party shall provide that a disclosure of a claimed invention shall be considered to be sufficiently clear and complete if it provides information that allows the invention to be made and used by a person skilled in the art, without undue experimentation, as of the filing" (article 15.9.9). Doubts have been raised as to whether this text implies a restriction on additional information being requested when the patent is disclosed. For legal and technical reasons the author does not agree with this interpretation. However, it deserves to be mentioned as a suggested potential implication of the FTA on the disclosure requirements.

FTAs have generally not incorporated a mandatory requirement for the disclosure of origin in the substantive IPR Chapter of the Agreement. However, the issue has sometimes been addressed elsewhere. For instance, in the case of the US-Peru FTA, the following elements have been agreed in a side letter:

a) Recognition of the importance of traditional knowledge (TK) and biodiversity, as well as their contribution to development.
b) Recognition of the importance of a) prior informed consent from the appropriate authority; b) equitable sharing of benefits from the use of TK and genetic resources; c) promoting quality patent examination to ensure the conditions of patentability are satisfied.
c) Recognition of the fact that access and benefit sharing can be adequately addressed by contracts.

Despite the recognition of the issues in the side letter, the text agreed is essentially on uncontroversial matters (e.g the importance of TK). In other words, the side letter does not address or respond to the more controversial aspects of disclosure of origin. Therefore, these provisions may not have an impact on critical issues discussed in the negotiations on an international regime.

ABS and Investment/Services Disciplines

The relationship between ABS and investment and services rules in FTAs is also of interest. For example, research services – including biodiversity-related research – is mentioned in the services chapter of CAFTA.

There may be legal implications of considering bioprospecting as a service and investment disciplines in FTAs may also be applicable. A common discipline in investment provisions is the prohibition (or restriction) of "performance" and other requirements placed on the investor and the investment. Arguably, such restrictions could limit the rights of countries to require, as part of ABS rules or procedures, technology transfer from the potential user of the genetic resources. Such technology transfer has been noted as an important benefit in the biodiversity context. Whether in fact this mandatory requirement for a foreign company imposed in the context of an ABS permit would constitute a violation of the investment disciplines remains unclear.

Nevertheless, a common feature of FTAs is a provision providing that, in case of contradiction between the investment chapter and other chapters, the latter prevail. Thus, the environmental chapter, which requires compliance with environmental laws in the country – including any access law or biodiversity law – would prevail over conflicting investment disciplines. A potential solution would be to require the investor/access applicant to comply with any technology transfer or other benefit sharing provisions in the context of the ABS permit. Any condition imposed on the applicant/investor would thus have its legal basis in the CBD and domestic environmental law.

From a legal perspective, some authors have pointed out the implications of considering "bioprospecting" as a service and the applicability of the investment disciplines contained in the FTA; in this regard, the prohibition (or restriction) of " performance" and other requirements to the investor and his investment can be mentioned; e.g. limiting the rights of the Country, as part of the access procedure, to require technology transfer from the potential user of the genetic resources (a benefit sharing condition before access is granted). This mandatory requirement imposed on a foreign company in the context of an ABS permit, could constitute a violation of the investments disciplines.

Finally, it is important to point out another implication of FTA' investment provisions. The investment Chapter usually requires Parties to provide National Treatment to a foreign investment (under certain circumstances and exceptions carefully negotiated and listed). A concern has been raised because some ABS laws discriminate between nationals and foreigners, creating a more favourable procedure for foreigners (e.g. India, Brazil, Sarawak). At this stage in the IR negotiations it is unclear to what extent, if any, the "access component" of ABS will be included. However, at least some proposals (e.g. those of the EU) have been put forward making a clear reference that ABS should not discriminate between nationals and foreigners.

Certificate of Origin/Compliance and Trade Disciplines[5]

One element ABS negotiations have focused on in order to respond to the call for user country measures, and to contribute to solving problems related to the monitoring and traceability of genetic resources, is by developing some form of certificate of origin/source/legal provenance – more recently named 'certificate of compliance'.

The idea of the certificate is to prevent or minimize problems generated by the existence of two different jurisdictions for ABS arrangements – that of the place where the material is collected and that of the place where research and development activities are carried out. The existence of an internationally recognized document would make it possible to check the legality of access at the place where the activity (patent, product approval, etc.) generates value, and to discover the subsequent use of the resources and the origin of the corresponding benefit-sharing. At the same time, this supposedly[6] would favour the creation of simpler access systems in provider countries, in that existing control mechanisms would be applied, via the certificate, in the later stages of research and development, thus helping to make the regulations on access to genetic resources more flexible. In this way, monitoring and regulation would be less strict during the access phase and stricter during the research and development phase, where control or check points would be established. This implies that the documentation would need to pass through the various buyers, but the monitoring points would be reserved only for certain milestones in the research and development process, such as those related to product approval, IPR applications, publications, the presentation of funding proposals, etc.

Many aspects still need to be clarified before this system can become operational, including (Fernández, 2004):

1. The designation of national authorities to issue certificates that are mutually recognized

2. The identification of conditions for verification of and compliance with the certificates, that is, the determination of which materials they would apply to, for what purposes, and at what moment or stage they would be verified
3. Exemptions
4. Provisions for cases in which it is not possible to identify the origin of the genetic resources, including benefit-sharing
5. Differential treatment of different sectors
6. Dispute settlement mechanisms
7. The creation of an international certificate register
8. How countries that are not parties to the IR will be handled
9. Provisions related to the resources contained in *ex-situ* collections prior to the Convention

Other aspects of interest could include:

1. Focus on what the certificate corresponds to: species, genes, specific biological samples, derivatives, etc.
2. Transaction costs of the certificate.
3. Different types of certificates: origin, legal provenance, source.
4. Characteristics of the system: simplicity, flexibility, avoidance of complex procedures.
5. Considerations regarding the product supply chain, etc.
6. Ability to comply with the objectives of the CBD, especially conservation.
7. Economic impacts and implications of the certificate for different actors (botanical gardens, etc.)
8. Content of the certificate.
9. Sanctions for non-compliance.
10. Lack of legislation on access.
11. Procedures for control and use of the Clearing House.
12. How to ensure that additional barriers are not created for the non-commercial exchange of resources.
13. Compatibility with international trade regimes,[7] etc.

Depending on the certificate's final design, some rules of the trade system (WTO or FTA) might apply to it, especially those related to technical barriers to trade. For instance, if the certificate is going to be checked at customs and if the legal consequences of not showing the same are the prohibition of the entry of the genetic resources- for which the certificate should have been issued - into a country. However, the potential implications of such rules on the certificate need to be better understood.

Capacity Building

Studies on the implementation of national ABS laws confirm the difficulties provider countries face in adequately complying with their current legislation. In the opinion of the author, in order to achieve CBD objectives, the importance of national frameworks and their application should not be neglected. This topic is closely related to capacity building. From this perspective, the international regime should contribute decisively to ensure the best possible application of existing legal frameworks on ABS, the strengthening of legal certainty and the creation of national capacities for that purpose.

FTAs often contain provisions on environmental cooperation (including capacity building activities) either in an Environment Chapter and/or in an Environmental Cooperation Agreement to be ratified separately. In each case, preliminary priorities have been set out for cooperation and capacity development in different areas or fields. ABS could be considered one of these areas and receive financial and other support from trade partners. These programmes could support capacity building activities under the international regime.

Discrimination against Countries without user measures in Place:[8] Flexibility through Governmental Reciprocality and Trade Implications

One step that source countries can consider, as a means of finding an appropriate standard of flexibility in addressing post-access monitoring and oversight, is the concept of reciprocality.

A source country might consider adopting legislation under which special ABS special procedures are only available for users operating under the jurisdiction of a country that has adopted certain measures. This approach might eliminate a common problem where applications that had been refused, because the authorities felt that did not have adequate guarantees or were uncertain of how exported material might really be used.

This solution should address the legal possibility for a country providing genetic resources to condition the granting of access to the existence of appropriate measures in the user country (User Measures). To condition the granting of access or to establish more favorable procedures, in the cases in which measures of this nature exist in the User Country, also has implications from international trade.

Often it is argued that the purpose of user measures is to provide an incentive for countries of origin to develop more flexible ABS rules and procedures and thus facilitate access in line with the CBD objectives. This was a 'key conclusion' of the first panel of experts in ABS: "Flexibility in providing countries is related to the extent that user countries and organizations implement measures that provide incentives or establish control mechanisms in order to secure the interest of providers over their resources."[9]

Description of the Measure

The proposed measure consists in introducing a mechanism that would provide for the existence of an additional, reciprocal and expedited access procedure (AREP) that would only be available for those countries who have effectively adopted user measures (including but not limited to the certificate of legal provenance and disclosure requirement).[10]

The issue of what exactly could be simplified (e.g. procedural or substantial issues) in the expedited procedure and how this would be determined has to be further explored. However, the mere existence of such mechanism would itself greatly assist those countries interested in developing effective access regimes. Additionally, this should be coordinated with the ongoing capacity-building efforts.

The measure is 'additional' in that it should not overrule the authority to determine access. Thus, the proposed alternative procedure would coexist with the general or standard procedure for ABS, which could then have more protective conditions.

However, the main advantage of the measure is that it could facilitate benefit sharing, so sending a much needed signal. First, as flexibility would increase so would the access activity and consequently the chances to generate benefits to share. Second, for any given country, it is more likely that benefit sharing will become significant in an aggregate manner rather than in an isolated way. Thus, as flexibility would take less time to be part of the system this would shorten the time for significant transactions to occur. As a result, significant benefit sharing would be facilitated.

In being available only to Parties to a binding instrument, for example, the measure would contribute in attracting signatories. If the international regime is to realize its potential in becoming the main legal structure regulating ABS and is to bring some degree of order and predictability to germplasm flows, it must attract wide adherence. The use of this kind of incentive has been successfully tested in relation to other Multilateral Environmental Agreements (MEAs).

The mechanism would require substantial information from National Focal Points (NFPs), which could be incorporated into databases of countries and user measures held in the CBD Clearing-House-Mechanism (CHM). The information would then be available for National Competent Authorities (NCAs) who would verify upon the eligibility of applicants and decide upon grating AREP.

National Experience in Discussing the Measure

The idea of introducing, in addition to the standard access procedure, certain expedited/simplified access procedures for nationals of jurisdiction where user measures have been adopted, was discussed within the environmental public sector in Mexico, during the deliberation of the Draft National ABS Law. In the end the Ministry of Environment was not persuaded due to misunderstandings over the exact limitations posed by international trade obligations and an over-dimensioning of the issue of discrimination. The general trade concern was over the discrimination that the measure entailed, without any further elaboration.

The Seychelles constitutes a good example of a country for which oversight and control of users will be nearly impossible. The Seychelles is not primarily a "user" of GR, and will probably not be able to build the level of infrastructure to monitor, test, or take other actions that impose restrictions on users. Its draft law, however, attempts to remedy these deficiencies, through the use of two kinds of provisions, legal mandates (basic user measures) and reciprocity. These provisions were included to give users and user countries an idea of the minimum that is expected from other countries in return for access and the right to use genetic resources.

These user provisions are very basic statements, however. In general, they simply require Seychellois who are utilising the genetic resources of other countries to

- Comply with the laws of the source country (Article 32);
- Comply with the terms and conditions of any relevant permit or contract (Article 33); and

- Notify the source country when the resources have been accessed (Article 34.)

For purposes of access legislation, however, a much more important provision is that which addresses questions of legal reciprocity and unconscionable terms and conditions. In this connection, Article 36 of the draft law states that

The provisions of this Part shall only apply in respect of the laws or other terms and conditions of access or utilisation of foreign jurisdictions providing equivalent or reciprocal protections to those contained in this Part, and shall not be enforceable where any relevant terms and conditions are declared unconscionable.

Both clauses of this provision are of interest legally. First, the reciprocity clause appears designed to create an incentive for user countries to adopt "user measures." In essence, it says that "if you don't protect our genetic resources from unauthorised exploitation, we won't do the same for you." Presuming that other source countries (with larger genetic-resource industry and research bases) follow this example, such an incentive might indeed develop. At the same time, that clause suggests that all that user countries must do is provide three of four unenforceable single sentence mandates, in order to meet their responsibility under Article 15.7.

In addition, the second clause might be interpreted to be an authority to declare foreign law invalid – another provision that might have negative reciprocal impacts, if a user country were to adopt and enforce it.

Trade Concerns: The Limitations

A wide variety of trade measures (TREM's) have been used in MEAs, either amongst parties or against non-parties. This includes reporting requirements on trade flows, labelling or other identification requirements, requirements for movement documents (such as permits or licenses, or systems of prior notification and consent), and export and/or import bans.

Particularly those TREMs aiming to provide means of enforcing a MEA (i.e. measures amongst parties and against parties) can give rise to considerable trade concerns. This is because they entail a discriminatory practice that might be incompatible with a basic tenet of the world trade system: *non-discrimination*. Non-discrimination is promoted mainly by operation of two principles: most-favoured-nation (MFN) and national-treatment (NT). The former requires Member Countries to extend the best treatment granted to like products from any other Member (Article I of GATT). The latter requires Members to extend the same treatment to domestic and imported like products (Article III of GATT).

However, GATT also contains general exemptions by virtue of which a Party can deviate from its basics obligations under certain circumstances, including the obligations not to discriminate. Pursuant to Article XX, measures aimed to protect the environment can be validly pursued under paragraph (b) on protection of human, plant and animal life and health; and paragraph (g) on protection of exhaustible natural resources. There are some conditions that have to be met in order to be able to benefit from these environmental exemptions. The measure must be the less restrictive to trade, must be related to the environment, and must not be, according to the " chapeau" , a disguised restriction on international trade, or applied in a manner which would constitute a means of arbitrary[11] or unjustifiable discrimination between countries where the same conditions prevail. Thus, in addition to the MFN and NT principles, discrimination is addressed in the T&E scenario through the chapeau of article XX.

In the same vein, in the environment field the international community has committed to avoid measures that constitute a means of arbitrary or unjustifiable discrimination.[12] Note however, that the consensus in both fields is limited to the excesses since clearly not all form of discrimination is *arbitrary or unjustifiable.*

In relation to potential trade implications of the measure, considering some of the understandings produced over the debate of MEA-WTO relationship, as well as the terms of the environmental exemptions embedded in the GATT and the inclusion of the notion sustainable development in the international trade system, it can be concluded that the proposed measure should be considered WTO compatible.

In sum, it can be safely argued that the measure proposed in this paper poses no major problems of WTO compatibility, considering:

- The precedents found in other MEAs and in the International Treaty for Plant Genetic Resources for Food and Agriculture.
- The terms of the exceptions of the Article XX of the GATT and its interpretation; and

Box I: Links between the International Regime on ABS and FTAs

IR component	FTA Implications
• Benefit-sharing/ Traditional knowledge	• Promotion of mechanisms to support/ recognise the importance of benefit-sharing (Side Letters addressing the issue). • Side Letters and other relevant provisions reaffirming the importance of TK and biodiversity for development. • In some commentators opinion potential restrictions on disclosure included in IPR Chapters. • Restrictions on the type and modalities of benefit-sharing requirements imposed on bioprospecting (investment disciplines and their applicability with regard to ABS activities). However, primacy of Environmental Chapter of FTA could solve this restriction, allowing the investor´s requirements (e.g. tech transfer) in the light of the obligation to enforce environmental laws (biodiversity related laws).
• Access	• Promotion of mechanisms to support/ recognise the importance of PIC from the competent authority (Side Letters addressing the issue). • Prohibition of discrimination between foreigners and nationals (ABS activities considered as services or investments[13]). However, primacy of the Environmental Chapter of FTA and recourse of other Treaty´s provisions and exceptions could solve this restriction.
• Support compliance with Prior Informed Consent (PIC) and Mutually Agreed Terms (MAT) of provider countries.	• Technical Barriers to Trade rules (or the reaffirmation of the WTO disciplines found in FTA) and their impact on a potential certificate of origin/ compliance (depending on its final structure; design; check points; legal consequences of non presentation of the certificate; etc). In accordance to some commentators disclosure of origin restrictions.
• Capacity Building	• Environmental Cooperation Agreements and capacity building in priority areas, including potential activities in ABS-related areas.

- The understandings that have emerged during the long debate of the relationship between MEAs and the WTO rules.

Concluding Remarks

This article has highlighted a number of links between Trade (focusing on FTAs) and the international regime for ABS that is currently being negotiated under the CBD (see Box I). Despite the theoretical speculations, it is still uncertain if and how FTAs might have an impact on the negotiating dynamics and country positions with regard to the international regime. So far, this has not seemed to be the case. With regard to the substantive content of the proposals submitted by the different countries or by regional groups in the negotiations, it is difficult to link the modifications of recent country proposals to the content of their FTAs (especially because the proposals do not include specific negotiating language).

More time and analysis will thus be needed in order to identify the potential impact of Trade and FTAs on the negotiations and final outcome of an international regime for ABS.

Endnotes

[1] Parts of this article are based on a previous article of the author, published in Biodiversity and regional and bilateral trade agreements: Implications for access and benefit-sharing negotiations, Bridges Trade and Environmental Review, Issue No. 3, ICTSD, Geneva, March 2008

[2] Concerning technical and legal aspects of disclosure of origin, readers are referred to the following studies which, in addition to being comprehensive, present some differing conclusions on various aspects: WIPO, Technical Study on Patent Disclosure Requirements Related to Genetic Resources and Traditional Knowledge, Study No 3, 2005; Sarnoff, Joshua and Correa, Carlos, Analysis of Options for Implementing the Disclosure of Origin Requirements in Intellectual Property Applications; UNCTAD, February 2006; Rojas, Martha et al., Disclosure Requirements, op. cit.; Sarnoff, Joshua, Compatibility with Existing International Property Agreements of Requirements for Patent Applications to Disclose the Origins of Genetic Resources and Traditional Knowledge and Evidence of Legal Access and Benefit Sharing, available at www.piipa.org; Ho, Cynthia, Disclosure of Origin and Prior Informed Consent for Applications of Intellectual Property Rights based on Genetic Resources. A Technical Study of Implementation Issues. Final Report, July, 2003; and, Hoare, Alison, Background Paper for the Chatham House Workshop: "Disclosure Requirements in Patent Applications - Options and Perspectives of Users and Providers of Genetic Resources." 9-10th February 2006; Energy, Environment and Development Program, Chatham House.

[3] For example, Brazil, the Andean Community, Costa Rica, India and Egypt, among others.

[4] Correa, Carlos, Alcances jurídicos de las exigencias de divulgación del origen en el sistema de patentes y derechos de obtentor, Research Documents, Initiative to Prevent Biopiracy, Year 1, No 2, August 2005.

[5] It is not my intent to develop the idea of the certificate in depth. For further detail, see the following documents: Dross, Miriam and Wolff, Franziska, New Elements of the International Regime on Access and Benefit Sharing of Genetic Resources: the Role of Certificates of Origin, BFN. Bonn, 2005; Fernandez, Jose Carlos, The Feasibility, Practicality and Cost of a Certificate of Origin System for Genetic Resources: Economic Considerations; in Yokohama Round Table: Toward Fair and Equitable Benefit Sharing: Instruments for the Effective Implementation of the Bonn Guidelines under the Convention On Biological Diversity; Yokohama, Japan, 11 March 2005; Tobin, Brendan, Cunningham, David and Watanabe, Kazuo: the Feasibility, Practicality and Cost of a Certificate of Origin System for Genetic Resources, working paper submitted to the Secretariat of the Convention on Biological Diversity, February, 2005.

[6] .An analysis of the causes behind processes to reform the implementation of ABS laws can be found in,Gatforth, Kathryn and Cabrera Medaglia, Jorge, Factors Contributing to Legal Reform for the Development and Implementation of Measures on Access to Genetic Resources and Benefit-Sharing, publication pending.

[7] On this last aspect, cfr. Louafi Salim, Morin, Jean Frederic, Certificates of Origen for Genetic Resources and International Trade Law, IDRRI, 2004, first draft.

[8] This section is based on a previous draft of the book Cabrera Medaglia, Jorge y Christian López Silva (2007). Addressing the Problems of Access: protecting sources, while giving users certainty. Gland, Suiza: UICN.

[9] Report of the Panel of Experts on Access and Benefit-Sharing, UNEP/CBD/COP/5/8, 2 November 1999, Conference of the Parties to the Convention on Biological Diversity, Nairobi, parr 151.

[10] A somewhat similar measure was suggested at the First Panel of the Experts of the CBD. However, it focused on the conduct of persons, not State. The measure recommended only referred to voluntary instruments and it only suggested simplifying the PIC procedures. See Report of-the Panel of Experts, op cit, Annex V.

[11] WTO panels have accorded special attention to flexibility in the application of the measure concerned. The more rigid and inflexible the application, the higher the likelihood that the measure is regarded as arbitrary and unjustifiable.

[12] As stated in Principle 12 of 1992 Rio Declaration and confirmed in paragraph 101 of the 2002 Johannesburg Plan of Implementation.

[13] Few ABS laws provide a more favourable treatment to nationals in the process of granting of the ABS permit.

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Bioindustry and the Convention on Biological Diversity: Japan's Experience

Seizo Sumida*

Abstract: In Japan, industry association and the government are working very closely to implement the ABS regime. This has yielded some very encouraging results which may provide guidelines for future policy options. The Japan Bio Industry Association, JBA, has been making efforts to build mutually beneficial relations with other countries as well that may provide genetic resources, by facilitating access to genetic resources and implementing fair and equitable sharing of benefits arising from the use of those resources.

Keywords: ABS, CBD, Japan.

Introduction

Since the Convention on Biological Diversity (CBD) entered into force in 1993, Japan Bioindustry Association[1] (JBA) has been steadily involved in the process of implementing CBD.

The Ministry of Economy, Trade and Industry (METI) is a competent national authorities on ABS in Japan. On behalf of METI, JBA has been implementing the access to genetic resources and benefit-sharing (ABS) provisions of the CBD, since 2002, in order to help the private sector and the scientific community to continue to build a win-win relationship with other countries. As part of this project, JBA has been participating in the meetings of the Ad Hoc Open-ended Working Group on Access and Benefit-sharing (WG-ABS) as well as the Conference of Parties (COP) to CBD for discussion of ABS and other issues. JBA has also been making efforts to build mutually beneficial relations with countries that provide genetic resources, by facilitating access to genetic resources and promoting fair and equitable sharing of benefits arising from the use of genetic resources in an appropriate manner.

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Bioindustry and the Convention on Biological Diversity

Currently, the market size (domestic sales volume) of modern biotechnology products and services in Japan for 2006 was worth 1,847 billion Japanese Yen (JY) (approximately equivalent to US$ 18 billion) per year.[2] The market has shown steady growth since 1989. If products of both conventional and modern biotechnology are combined, the market size in 2005 was JY 7,692 billion (approx. US$ 77 billion). The size of the world pharmaceutical market in 2005 was US$ 601.4 billion. Japan's share was approx. US$ 66 billion (11 per cent of the world market), which is the second after the United States (44 per cent).[3]

Historically, Japan's pharmaceutical industry has strengths in microbial natural product-based drug discovery, as demonstrated by the world-wide blockbuster drugs such as pravastatin and tacrolimus. An example of more recent commercial success is micafungin. Some other compounds originating from Japanese natural products are currently being tested in the clinical phases.

There are several reasons for the Japan's strengths in microbial natural product-based drug discovery.[4] Japan has traditionally developed fermentation industries using *Aspergillus*, *Saccharomyces*, and other microbes. This tradition helped to nurture expertise in applied microbiology. For example, more than 100 years ago, Jokichi Takamine, a pioneer in biotechnology in both Japan and the United States, developed and patented microbial enzymes for the first time in the world. Modern fermentation processes for amino acids and nucleotides have bloomed in Japan since late 1950s. Discovery and development of natural product-based drugs require a wide diversity of researchers in different disciplines. Success depends on well-organized collaboration between these experts rather than one genius. This type of research collaboration seems compatible with Japanese culture.

However, the percentage of small-molecule drugs worldwide that include those of natural product origin are envisaged to decrease substantially in the coming decades. On one hand, modern biotechnology-based drug discovery (for large-molecule drugs such as antibody drugs) attracted considerable attention of the corporate management in Japan. On the other, CBD has negatively affected corporate management's incentives for investment in natural product-based drug discovery, because of uncertainty about the regulatory procedures of a number of developing countries that are potential providers of genetic resources. Major Western pharmaceutical companies either withdrew or reduced their focus in natural product-based drug discovery. Japanese pharmaceutical companies have been affected by this trend, but a number of them still manage to keep the function of their natural product drug discovery on a smaller scale. Continuous efforts are needed to keep the natural product drug discovery alive. In this sense, CBD-based collaboration with developing countries, such as efforts by Nimura Genetic Solutions in Malaysia, Mercian Corp. in Indoensia and HyphaGenesis Inc. in Vietnam, will be essential. MET and JBA have been implementing ABS provisions of the CBD,in order to help the private sector and the scientific community to continue to build a win-win relationship with other countries. The evolution of CBD-ABS implementation in Japan is described later in the section on development of Japan's ABS guidelines for users.

Experiences in Research Cooperation Projects on Conservation and Sustainable Use of Tropical Biodiversity between Japan and Southeast Asian Countries

Mutual understanding and trust are the basis to develop a good human relationship. Anticipating the advent of CBD-era, METI and JBA started planning bilateral research cooperation projects with Southeast Asian countries in early 1990s. We had a long-term objective to continue to develop good relationships with other countries. ABS was not an immediate target. The objective was to get to know each other in the upcoming CBD context.

The Bilateral Research Cooperation Projects between Japan and each of Thailand, Indonesia and Malaysia started in April 1993 and continued for six years until March 1999. The projects exchanged a total of 591 Japanese and Southeast Asian scientists, installed the most-needed equipment and instruments in the local research facilities, and sponsored domestic research programs. The Japan Bioindustry Association (JBA) carried out these projects entrusted by the New Energy and Industrial Technology Development Organization (NEDO) under the guidance of Ministry of International Trade and Industry (currently called METI).[5]

The research activities were mostly conducted by the scientists from universities and public research institutes. A total of 389 Japanese scientists were dispatched to the three Southeastern countries for on-site collaborative research, whereas a total of 202 scientists from those three countries were invited to Japan for joint research or training for technology transfer. A variety of interesting results were gained in the research projects.[6] The projects' cumulative budget was approximately 1 billion yen (approximately US$ 10 million) over 6 years on Japan's side, including costs for personnel, equipment and instruments, research and training, and traveling. The JBA secretariat, in cooperation with its counterparts, worked out mutually acceptable, transparent and practical procedures for handling biological resources, including Material Transfer Agreements for scientific research purposes. The Bilateral Research Cooperation Projects helped all the participating countries to develop mutual understanding and confidence which became the foundation for the subsequent developments, including those described in the Section on Experiences of Japan's National Institute of Technology and Evaluation (NITE) in Research Cooperation in Microbial Taxonomy with Other Countries.

As policy relevant lessons, JBA learned that biological resource centers, as repository of biological materials and related information, have become an essential part of the scientific and technological infrastructure for each country in the era of Convention on Biological Diversity, and that they should therefore be strengthened. JBA also learned that involvement of industries would be essential in future cooperation projects on biological diversity, because industries have the actual capabilities to create benefits from utilization of biological resources.

In fact, after several years of preparation, some Japanese companies established its laboratories in these countries and have since been conducting research activities in compliance with the CBD and their national laws. In retrospect, the mutual understanding and trust that had been developed through the Research Cooperation Projects in 1990s were foundations for these developments

Objectives of the Arrangements

The primary objectives of the projects were;

(1) To assist the participating countries in their own efforts to conserve and use biodiversity in a sustainable manner;

(2) To train the participating scientists and help further develop their scientific skills through collaborative research with installment of state-of-the-art equipment and instruments in their countries.

Content and Implementation of the Arrangements

Japan-Thailand Project

As the basic agreement, Memorandum of Understanding (MOU) was concluded between NEDO, Japan and The National Science and Technology Development Agency (NASTDA), Thailand. Scientists and researchers from a number of national research institutes and universities of both countries participated in the joint research activities. The subjects of the cooperation projects were as follows:

A. Taxonomic analysis, ecosystem evaluation and monitoring
    1.1 Feeding strategies of primates
    1.2 Improvement of microbial culture collection systems: Use of classification/identification methods based on DNA
B. Conservation of biodiversity through man-made ecosystems
    2.1 Interactions among different organisms within a man-made ecosystem
    2.2 Genetic diversity analysis of artificial ecosystems
    2.3 Socio-economic and ethnological analysis of an artificial ecosystem
C. Use of bioresources
    3.1 Use of bioresources: Screening of new bioactive substances found in plants and their applications
    3.2 Study of traditional use of plant resources

Japan-Indonesia Project

The MOU was concluded between NEDO, Japan and The Agency for the Assessment and Application of Technology (BPPT), Indonesia. Scientists and researchers from a number of national research institutes and universities of both countries participated in the joint research activities. The subjects of the joint research were:

A. Taxonomic analysis, ecosystem evaluation and monitoring
    1.1 Microbial culture collection systems
    1.2 Plant conservation techniques:
        (1) Conservation of plant diversity
        (2) Tissue and cell cultures of tropical plant species
        (3) Development of DNA techniques for the evaluation of biological diversity
B. Utilization of tropical bioresources
    2.1 Utilization of microbial resources

2.2 Utilization of plant resources
2.3 Elucidation of symbiosis between plant and microorganism and its utilization

C. Promoting the establishment of "Tropical Bioresources Industrial Development Center" in Indonesia

Japan-Malaysia Project

The MOU was concluded between NEDO, Japan and The Standards and Industrial Research Institute of Malaysia (SIRIM). Implementation of the cooperation project on Malaysian side was conducted by National Biotechnology Directorate (NBD), The Ministry of Science, Technology and the Environment (MOSTE) Malaysia. Scientists and researchers from a number of national research institutes and universities of both countries participated in the joint research activities. The subjects of the research cooperation were:

A. Ecosystems and monitoring
    1.1 Biodiversity databases and gene banks
    1.2 Evaluation and monitoring of marine ecosystems
    1.3 Ecosystem evaluation and inventory development based on advanced technologies

B. Utilization of tropical bioresources
    2.1 Screening and separation of bioactive compounds produced by microorganisms and plants
    2.2 Evaluation of therapeutic and toxic potentials of natural products

Experiences of Japan's National Institute of Technology and Evaluation (NITE) in Research Cooperation in Microbial Taxonomy with Other Countries

Microbial resource centers are fundamental to preserving and harnessing microbial biodiversity and genetic resources. The availability of precisely identified and validated microbial resources is essential for scientific research and industrial and other applications. In many cases, microbial resource centers are centers of excellence for preserving microbial biodiversity and training microbial taxonomists. In recent decades, academia in Japan has experienced a conspicuous decline in number of taxonomic experts trained to discover, identify, describe and classify microbial biodiversity. For example, when professors in microbial taxonomy retire, the universities often suppress the posts, and recruit researchers with disciplines more 'glamorous' than taxonomy. This trend has led to drastic reduction in graduate training in microbial biodiversity research. Becoming increasingly concerned about the situation, Japan's academia and industry together made a recommendation to the government that a national microbial resource center be established the function of which is to be adapted to the principles of the Convention on Biological Diversity (CBD) and the genomic era. In response to this recommendation, the Japan's government, in 2002, created a microbial resource center within the National Institute of Technology and Evaluation (hereafter referred to as NITE-BRC).

Organization of NITE-BRC

Within NITE-BRC, the functions of the microbial culture collection and genomic research are integrated to promote synergy and to add value to the microbial resources and associated data. The functional organization of NITE-BRC is as follows:

- Preservation and distribution of microbial resources as references
  NITE-BRC collects, identifies, preserves and distributes potentially useful microorganisms and cloned genes to users to promote basic research as well as industrial and other applications. These strains serve as references for diversified purposes. As a separate entity, NITE-BRC also has a patent microorganism depositary in accordance with the Budapest Treaty.
- Microbial genome analysis
  The function of microbial genome analysis group is integrated within NITE-BRC. Once genome analysis of a microorganism is completed, the results are released for public use in the "Database of the Genomes Analyzed at NITE" (DOGAN).[7]

Concept of International Collaboration and "Tsukuba Statement"

The concept of international collaboration that has been leading NITE-BRC is consistent with the 'Tsukuba Statement' issued by the Global Taxonomy Initiative (GTI) Programme of Work in Microbiology that took place in Tsukuba, Japan in October, 2003[8] (see the box below). The GTI is a cross cutting issue of the CBD. In the Tsukuba meeting, delegates from Asian and Oceania countries participated.

Key points are excerpted from the Tsukuba Statement as follows:

1) Strategic inventory of microbial diversity should be developed in each country.

2) Taxonomists themselves should recognize the importance of their role for solving biodiversity problems. National governments should establish laboratories and institutes for applied microbial taxonomy.
3) Developed countries are requested to draw up and implement a plan for the advancement of microbiology in collaboration with developing countries.
4) Providers and users of microbial resources must respect and follow the CBD and the Bonn Guidelines. National governments should

Tsukuba Statement

Tsukuba, Ibaraki, Japan, 9 October 2003

Global Taxonomy Initiative (GTI) and Microbial Taxonomy[9]

1. For the purpose of accumulating knowledge on and the full understanding of microbial diversity, predicting its change, and assessing the impact of any change, and for the purpose of developing the technology and measures for sustainable use and the fair and equitable sharing of benefit, a strategic inventory of microbial diversity should be implemented in each country.
2. Taxonomists themselves should recognize the importance of their role for solving biodiversity problems. In order to sustain and advance microbial taxonomy and to prevent the loss of and increase the number of microbial taxonomists, national governments should establish laboratories and institutes for applied microbial taxonomy. Microbial taxonomists must exert all their powers to advance microbiology.
3. Recognizing the importance of microbial taxonomy for the strategic inventory of microbial diversity, developed countries are requested to draw up a plan for the advancement of microbiology in collaboration with developing countries and the plan should be implemented.
4. Providers and users of microbial resources must respect and follow the CBD and the Bonn Guideline. National governments should pay attention so that the CBD does not hinder strategic inventory of microbial diversity. Providers must accelerate acquisition of strains and specimens used for taxonomy. In particular, national governments should not excessively restrict the academic use of biological resources, especially type strains of bacteria and reference strains of fungi and algae. As much as possible of the information associated with these strains should be made available to the public.
5. In addition to the strains referred to above, the data from the inventory work in each country should be managed within database systems which support global networking, and which are effective for supporting the clearing house mechanism of transfer of microbes and guarantees continuity between generations.

pay attention so that the CBD does not hinder development of strategic inventorying of microbial diversity.

5) The data from the inventory work in each country should be managed within database systems which support global networking.

As stated at the beginning of this section, the availability of precisely identified and validated microbial resources is essential for scientific research and industrial and other applications. On a long term basis, microbial taxonomy is an essential tool to implement the three objectives of CBD, including ABS.

Experiences of NITE-BRC in Collaborative Research with Other Countries

NITE-BRC signed memorandums with governmental organizations in Asian countries; with Indonesia, Mongolia and Vietnam for collaborative research for the conservation and sustainable use of microbial resources, and with China and Thailand for collaboration between culture collections. The framework and content of the joint projects vary, on a case by case basis. The following is an example of collaborative research:

— Sharing of research results
— Installation of equipments for capacity building
— Collaboration in sampling, isolation and taxonomical characterization
— On-site workshops for technology transfer
— Hosting of researchers at NITE-BRC facilities for joint research and/or technology transfer

Note that, since this is a collaboration project between government institutes, the form of benefit sharing is non-monetary.

The Asian Consortium for the Conservation and Sustainable Use of Microbial Resources (ACM)

NITE contributed to the establishment of the Asian Consortium for the Conservation and Sustainable Use of Microbial Resources (ACM) with 12 Asian countries. The ACM is aimed mainly at the following activities:

— Human resource development and capacity building to manage culture collections of microbial resources for ex-situ conservation in each member country
— Establishment of the network of biological resource centers and

the database of culture collections of microbial resources with a common interface

- Development of the material transfer system to facilitate international collaborative research among the member countries in compliance with the CBD

These activities in the region have been useful for the streamlined and effective implementation of access to microbial genetic resources, benefit-sharing and capacity-building on the basis of mutual understanding and goodwill, consistent with the principles of CBD and the Bonn Guidelines.

Development of 'Japan's ABS Guidelines for Users'[10]

Soon after the adoption of the Bonn Guidelines in February 2002, JBA translated them into Japanese. Using the Japanese translation, JBA disseminated the Bonn Guidelines by organizing more than 8 public seminars in major cities across the country during 2003 and 2004. This helped to enhance the awareness of genetic resources users, i.e. companies and researchers, about the Bonn Guidelines.

As the Bonn Guidelines became better understood in Japan, a number of users expressed their views that descriptions of the Bonn Guidelines were often too general to be helpful for them to cope with their practical needs. They emphasized a need for user-specific and user-friendly guidelines. Taking these experiences into consideration, METI decided to develop user-specific guidelines on the basis of the Bonn Guidelines and the CBD. In consultation with experts from industry and academia, METI started working on such guidelines in cooperation with JBA in 2004. The Guidelines on Access to Genetic Resources for Users in Japan ("Japan's ABS Guidelines for Users" for short) were completed and published in Japan in March 2005.

The Japan's ABS Guidelines for Users aim to help both providers and users of genetic resources to build win-win relationships, and to minimize the risk of getting involved in problems, while ensuring business flexibility. To promote their dissemination, JBA held since 2005 more than 12 public seminars in 6 major cities across the country. Its English translation was completed in February 2006.

Governmental Support for Users of Genetic Resources

On the basis of the Japan ABS Guidelines for Users, METI and JBA have developed a number of tools to support users of genetic resources.

- Bilateral workshops and meetings with CBD officials of providing countries:
  In order to promote development of partnership between users of genetic resources and providing countries, JBA, supported by METI, invited CBD officials (or experts) to Japan for information exchange at public workshops or meetings. They were requested to present information to the audience on their national policy, laws and regulatory systems relevant to ABS implementation. In some cases, JBA went to providing countries for information exchange. So far, JBA and METI.have held such bilateral workshops or meetings with the following countries; Australia, Brazil, Bhutan, China, India, Indonesia, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Singapore, Thailand and Vietnam.
- JBA's specialized website for ABS-related information on providing countries:
  JBA created a Japanese-language website specialized for disseminating information on ABS-related policy, laws and regulation of different countries, for users of genetic resources.
- JBA's Help Desk:
  JBA has been involved in the CBD matters since 1993. Based on this experience, JBA gives, to users of genetic resources, advice on ABS matters to those who have questions or problems, free of charge and on a confidential basis. Since 2005, JBA has handled more than 90 cases of such consultation, as of April 2008.

Concluding Remarks

Our approach is based on mutual understanding and trust. We choose partners when both sides feel confortable with each other from that perspective. So far, we feel that this approach has been working. The following statement is my personal view.

Social and economic situation is different in different countries. Therefore, domestic needs are different, national policy is different, and, in turn, laws and regulatory systems are different. However, even under these circumstances, different peoples can successfully collaborate if they identify a point of mutual interest. Key to success is mutual understanding. Steps for win-win partnership development would be as follows:

1) Understand each other's national situation.
2) Set a mutually agreed target, and jointly develop practical and

effective procedure for collaboration based on the national laws of the providing country, or the principles of CBD and the Bonn Guidelines if there is no such law.

3) Help each other to overcome risks, achieve the target and generate benefits.

4) Share the benefits in a fair and equitable manner based on the agreement made in 2.

Endnotes

[1] JBA is a non-profit organization dedicated to the promotion of bioscience, biotechnology and bioindustry. JBA was established in 1942 through the support of industry, academia and government. Today, JBA functions as a think tank and a platform for cooperation among scientists, technologists, corporate managers and policymakers.

[2] Nenkan (2007).

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[4] ibid

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[6] ibid

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[9] ibid

[10] Sumida (2008).

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Access and Benefit Sharing: Issues Related to Marine Genetic Resources

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Abstract: Since the entry into force of the CBD in 1993, countries have struggled to find answers to several questions related to ABS issues and have spent considerable amounts of time, energy and money in understanding how to operationalise these principles. One critical area that is beginning to appear during the discussions under the international regime is the status of marine genetic resources with a particular emphasis emerging on genetic resources available in areas beyond national jurisdiction. This paper presents some key legal and policy issues that negotiators of the international regime on ABS need to consider in relation to marine genetic resources.

Keywords: CBD, ABS, Marine, Genetic Resoruces.

Introduction

One of the key innovations of the UN Convention on Biological Diversity (CBD) was the way it sets out key principles relating to Access and Benefit Sharing (ABS) in relation to genetic resources. For example, Article 15 of the CBD on Access to Genetic Resources states that each Contracting Party shall endeavor to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties. Access to genetic resources shall be subject to prior informed consent of the Contracting Party providing such resources. Each Contracting Party shall endeavor to develop and carry out scientific research based on genetic resources provided by other

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Views and opinions expressed in the paper are those of the authors and not the organizations they represent.

Contracting Parties with the full participation of such Contracting Parties. Moreover, each Contracting Party is required to take legislative, administrative or policy measures with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the Contracting Party providing such resources.[1]

At the same time, it is also one of the most contentious aspects of the Convention because of limited experience of countries in dealing with ABS besides ABS discussions spanning social, economic and cultural arenas. Since the entry into force of the CBD in 1993, countries have struggled to find answers to several questions related to ABS issues and have spent considerable amounts of time, energy and money in understanding how to address these questions. Though more than six years were spent on developing a voluntary set of guidelines on ABS (the Bonn Guidelines) in 2002 countries quickly moved on to the development of an 'international regime' on ABS with limited focus on implementing/using the Bonn Guidelines. In 2006 Parties to the CBD decided that they will have to complete negotiations for the international regime by 2010: However, this process of defining the nature, scope, objective and elements of the regime seems to be taking longer than expected.

One critical area that is beginning to emerge during the discussions under the international regime is the status of marine genetic resources with a particular emphasis emerging on genetic resources available in areas beyond national jurisdiction. This paper presents some key legal and policy issues that negotiators of the international regime on ABS need to consider in relation to marine genetic resources. The intention on the paper is not to provide a prescriptive idea for the negotiations, but provide an information compilation which may provide useful to negotiators to consider when finalizing the international regime on sectoral issues such as marine genetic resources and links to other multilateral negotiation processes.

Marine Genetic Resources

In recent years the question of the status of genetic resources of marine areas both within and beyond national jurisdiction has been a subject of debate in the forums associated with the Convention on Biological Diversity, the International Seabed Authority, the United Nations Informal Consultative Process on the Law of the Sea, the annual debates of the United Nations General Assembly on Oceans and the Law of the Sea, and more recently, in the deliberations of Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction. Discussions in these forums has focused on three main issues pertaining to both areas within and beyond national jurisdiction: access and benefit sharing in relation to marine genetic resources; the establishment of marine protected areas (MPAs); and the regulation of mineral prospecting operations at hydrothermal vents sites and, more generally, of environmental impacts of human activities in open and deep ocean areas[2]. In addressing questions associated with access and benefit sharing in relation to marine genetic resources the international community should be mindful of the consequences for integrated oceans governance of failing to recognize the linkages between those issues.[3]

Marine Prospecting

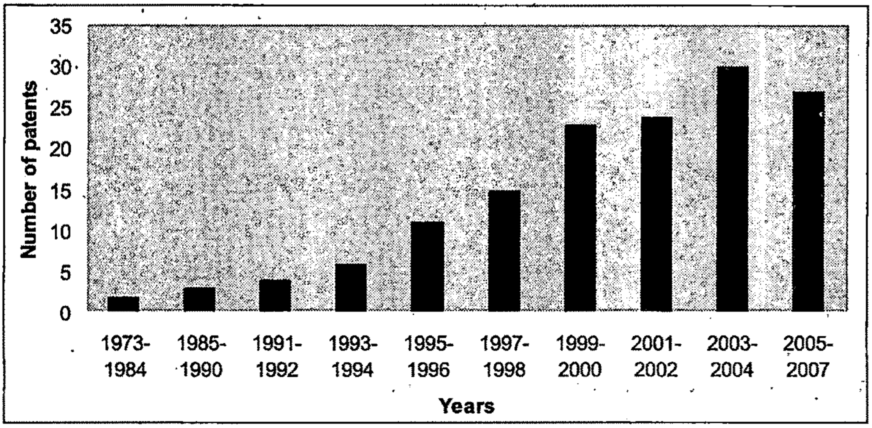
While there is a considerable divergence of views within the international community as to the precise meaning of the term "bioprospecting", at least in the context of marine genetic resources the term "bioprospecting" is more accurately defined as including the entire research and development process from sample extraction by public scientific and academic research institutions (which are generally but not exclusively funded by governments), through to full scale commercialization and marketing by commercial interests such as biotechnology companies.[4]

The focus of research on marine genetic resources is gradually becoming broader and also encompasses deep sea genetic resources as well as genetic resources from other areas beyond national jurisdiction such as Antarctica. According to a recently published study[5] at least 135 patents relevant to marine genetic resources were filed in the period from 1973 to 2007 (see Figure 1 below). The search undertaken for the purposes of that study was conducted using simple key words including the terms 'marine genetic resources' and should therefore be considered as purely indicative.

The patents identified in that study were classified according to categories reflecting six domains of application: chemistry, pharmacology, cosmetics, food, agriculture and health care.

Actual patenting activity is probably much greater than that limited search suggests. For example a subsequent study published in 2008 identified

Figure 1: Number of Patents involving Marine Genetic Resources filed from 1973-2007



Source: Vierros et. al 2007.

at least 20 patent and or patent applications based on or derived from marine sources in the Arctic alone.[6] These patents fell into seven broad categories of potential or actual use including medicines or pharmaceuticals, animal health care products (including aquaculture), food technology, enzymes with industrial applications, enzymes with life science research application, cosmetics and skin care, and nutraceuticals (including dietary supplements and other health products.[7]

It is very difficult to clearly quantify the monetary value of marine biotechnology due to the lack of clear global data.[8] Although there have been a number of studies on the commercial value of marine biotechnology, it is difficult to accurately place a figure on the commercial value of marine biotechnology due to variations in assessment methodologies.[9] Some studies have attempted to give a global view of the marine biotechnology industry. For example, one recent study estimated that in 2004 marine biotechnology globally was valued at 2.2 billion excluding aquaculture, seaweed and processing related industries (Douglas-Westwood Limited 2005). Other studies have focused on specific market values of industries commonly using marine genetic resources and approximate annual sales of selected marine-based products.[10] One cancer-fighting agent alone sourced from marine sources is estimated to have annual sales of US$1 billion in 2005.[11] Another recent study estimates that in 2002, global sales of marine biotechnology products, including anti-cancer compounds, antibiotics and antivirals, were estimated at about US$2.4 billion.[12]

Despite all of these studies there has so far been no single authoritative valuation of the marine genetic resources and their commercial uses and there is little if any clear data on the commercial use of marine genetic resources sourced from marine areas beyond national jurisdiction. Unlike the debate surrounding climate change there has so far been no "Stern Review" for the oceans and marine genetic resources in particular. Moreover, an eventual monetary valuation of marine genetic resources should take into account the values of the services of deep sea ecosystems.[13] Such a review is long overdue.

Legal Issues Concerning the Commercial Use of Marine Genetic Resources

Marine genetic resources found within areas of national jurisdiction are to be accessed and used according to the relevant provisions of the 1982 Law of the Sea Convention (LOSC), the CBD and other relevant international agreements. The LOSC does not provide a definition of the term 'marine areas beyond national jurisdiction', but it is generally accepted that the term 'marine areas beyond national jurisdiction' refers to the two discrete jurisdictional zones referred to in the LOSC known as the 'High Seas' and the 'Area'. Following the provisions of Article 86 of the LOSC the 'High Seas' may be regarded as all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State. The 'Area' is defined in Article 1(1) of the LOSC as "the sea-bed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction". Uncertainty exists as to the extent of coastal State jurisdiction over marine genetic resources on the continental shelf beyond the Exclusive Economic Zone (EEZ). This uncertainty relates primarily to the sovereign rights of the coastal state over the so called sedentary species under LOSC. But as this subsidiary issue has received little attention in the international debate so far this question is not addressed in this paper (for further examination of this issue see publications such as (Allen 2001), (Korn et..al 2003) and (Leary 2007)). For the purposes of this paper the term 'marine areas beyond national jurisdiction' may be regarded as referring to all parts of the sea that are not included in the EEZ, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State including the water column and the Area.

It is worth noting that in marine areas beyond national jurisdiction two separate legal regimes apply to the 'High Seas' and the 'Area'. As a matter of customary international law and under the LOSC it is generally accepted that marine genetic resources are freely accessible to all, that is to say access to and the sampling of marine genetic resources in the High Seas is regarded as a legitimate exercise of freedom of the High Seas. In that regard it is worth noting that the list of High Seas freedoms listed in Article 87(1) of the LOSC are not exhaustive and for present purposes it is worth noting that "freedom of the high seas" includes, "*inter alia*" "freedom of navigation", "freedom of scientific research" and "freedom of fishing".

The position with respect to the 'Area' is more complex. It is generally accepted that access and benefit sharing in relation to the genetic resources of the Area is unregulated. Such activities fall outside the operation of the main international legal regime applicable to the deep sea established by Part XI of the LOSC and the 1994 Implementation Agreement in relation to Part XI of LOSC (the Part XI Agreement).[14] These treaties established a very detailed international regime governing exploitation and benefit sharing in relation to the mineral resources of the Area. Principally this regime vests the International Seabed Authority with a mandate to regulate the exploitation of the mineral resources of the 'Area'.

However, the genetic resources of the deep sea do not fall within the 'resources' to which that regime applies.[15] This is because the definition of 'resources' contained in Article 133(a) of LOSC limits the International Seabed Authority's mandate to "all solid liquid or gaseous mineral resources in situ in the Area at or beneath the sea-bed, including polymetallic nodules". As such the International Seabed Authority only has a mandate to regulate exploitation of those mineral resources. Its mandate does not extent to the genetic resources of the 'Area'. However, the International Seabed Authority has recently expressed a desire to address issues associated with the sustainable management of deep sea biodiversity to the limited extent that its mandate allows (principally with respect to mining).

There has been some debate in various international forums as to whether deep sea genetic resources and or marine genetic resources more generally in areas beyond national jurisdiction should be regarded as the common heritage of mankind [sic], as that term is used in LOSC. In the case of marine genetic resources in the High Seas it is unlikely that this is correct as this is inconsistent with such resources being subject to High Seas freedoms.

In the case of the genetic resources of the Area the common heritage of mankind [sic] status of genetic resources as distinct from deep sea mineral resources is disputed. Regardless of whether or not these resources are regarded as or subsequently designated as the common heritage of mankind or not, this still does not address the core issue of the absence of regulation of access and benefit sharing in relation to these resources in areas beyond national jurisdiction. Even if marine genetic resources were regarded as the common heritage of mankind there is still no mechanism provided for in LOSC to regulate access and benefit sharing in relation to these resources.[16]

It is also worth noting that certain marine species found in the Area possess pelagic larval life stages, which implies that, for a certain period of their life cycle, these resources are to be found in the water column. Issues related to different stages of the life cycles of marine genetic resources (which may be pelagic or benthic, depending on the species in question) are currently not adequately reflected in the international discussions on these resources.

Perhaps even more significant than the debate as to the applicability or otherwise of the concept of the common heritage of mankind is the role played by patents in the exploitation of marine genetic resources. The grant of a patent in relation to development of biotechnology from marine genetic resources is the key legal act in the bioprospecting process.[17] Unlike other resources of the ocean such as minerals or fish, in the case of marine genetic resources often one small sample can be developed into a new product, while in some areas of research often the final commercialized product is based on a derivative and no subsequent sampling of the original organism is required. This is not always the case though, as some research on certain new drugs requires harvesting of large quantities of the marine organisms. Ultimately only the person who holds the patent on the new product developed can lawfully exploit that product or license others to exploit the product. Thus even if a third party could obtain another sample and reproduce the initial biotechnological product, that third party's ability to exploit that product would be subject to the patent rights held by the first party to patent the product.[18]

Importantly, it is worth noting that the grant of a patent is essentially a sovereign act of a nation State, albeit to an extent subject to international treaties such as the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) and the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the

Purposes of Patent Procedure (the Budapest Treaty).[19] This is especially significant in the case of biotechnology derived from genetic resources sourced beyond national jurisdiction because regardless of where the original genetic resource is sourced, the grant of a patent is always something that occurs within a State's jurisdiction. This means that the rights of a patent holder are determined by the domestic law of the State in which the patent was granted (subject to that State's international legal obligations including obligations under TRIPS and the Budapest Treaty). Thus rights in relation to patents (as opposed to the question of access rights) are not affected by the absence of a specific regulatory regime in areas beyond national jurisdiction.[20]

Key Issues that the International Community Needs to Address with Respect to Genetic Resources from Areas beyond National Jurisdiction

The core issue of course is whether or not benefits associated with exploitation of marine genetic resources should be shared by the entire international community, not just by the wealthy developed states with the capacity to exploit such resources, which remain difficult to access, technologically and financially.[21] Once the international community reaches a consensus with respect to the need for access and benefit sharing to be regulated then arguably the single most important step will be to link that regime to international and domestic regimes dealing with the grant of patents with respect to marine genetic resources.[22]

One author has proposed that this might be achieved with minimal change to the existing patent system.[23] This proposal suggests that benefit sharing in relation to such resources might be achieved by means of royalties payable in relation to patents granted in relation to deep sea and other marine genetic resources sourced from areas beyond the limits of national jurisdiction. Thus it has been suggested that this could be achieved by establishing a form of trust fund with royalties to be made payable to that trust fund. The payment of royalties could be made a condition of the grant of the patent which would be imposed under domestic law. In addition to existing disclosure requirements, those depositing microbes in type culture collections under the Budapest Treaty might also be required to identify the exact geographical location of where the microbe is sourced thus making it possible to identify whether or not the proposed benefit sharing regime applies.[24] Much of the scientific literature reviewed for the purposes of this and previous studies have contained information on the location where the original samples were taken from, often identifying precise co-ordinates of latitude and longitude. Although this is not always the case.

It is important to note that the proposal noted above would only extend to genetic resources sourced from areas beyond national jurisdiction as those within national jurisdiction already fall within the regime recognized by the CBD. A few parameters for the proposed royalty have also been suggested and should also be noted. Firstly it has been suggested that a good benchmark figure may be similar amounts paid under access and benefit sharing arrangements within national jurisdiction.[25] Secondly it has been suggested that it would be preferable that any such royalty be linked to the actual sale of products derived from such genetic resources. This would minimize the royalty becoming a disincentive to research and development.[26]

Questions also need to be considered in relation to the environmental impact of activities such as marine scientific research which provide the samples for research and development. It is not yet clear whether the scale of the environmental impact of such activities warrants regulation. Clearly further detailed scientific research on the nature and scale of such activities is required.[27] Before any regime is imposed to regulate the environmental impact of marine scientific research, if in fact such a regime is warranted in the first place, it is important that there is close examination of the impact of such a regime on scientific research. Ill conceived and hasty regulation runs the risk of setting back very valuable scientific research.[28] At a minimum, as earlier studies have noted (eg (Vierros et. al 2007) and (Leary 2007)) any regime must be developed in consultation with the scientific community who are both stakeholders and advisors to policy makers.

However, as evidence is emerging that marine scientific research does have some environmental impact (especially at sites that are repeatedly visited) a precautionary approach would mandate that the international community consider seriously the nature and scale of its impact, and the extent to which regulation is warranted.[29] There are precedents for the sustainable management of the environmental impact of science beyond national jurisdiction. The most obvious example is the mechanisms of the Madrid Protocol to the Antarctic Treaty which is primarily implemented via domestic legislation of contracting parties. The Madrid Protocol is a suitable model for regulating the environmental impact of scientific research in areas beyond national jurisdiction including the deep sea.[30] Compliance with an environmental impact assessment mechanism modelled on the Madrid Protocol might be enhanced if compliance with any such regime was made a condition of receiving government funding for scientific research as already occurs in several jurisdictions.[31] Such an environmental impact assessment regime might also be incorporated into regimes for the management of MPAs in areas beyond national jurisdiction.[32]

Issues under CBD

The other main treaty of relevance to these issues is the CBD. However, the CBD appears to have only a limited application to activities in areas beyond national jurisdiction. In a meaningful practical sense the CBD would only appear to apply to activities beyond national jurisdiction to the extent that States regulate the activities of their own nationals. So far no State regulates the activities of its nationals with respect to the genetic resources in areas beyond national jurisdiction.[33]

Under Article 4, the jurisdictional scope of the CBD is limited to components of biodiversity found in areas within the limits of national jurisdiction. Deep seabed and other marine genetic resources in areas beyond national jurisdiction are therefore excluded from the CBD's scope. However, the CBD applies to processes and activities, regardless of where their effects occur, carried out under the jurisdiction or control of states within or beyond areas subject to national jurisdiction. As observed by Arico and Salpin (2005) "it follows that activities undertaken in the High Seas or the Area, including navigation, scientific research, bioprospecting, exploration, exploitation dumping and tourism, fall within the scope of CBD if they are carried out under the control or jurisdiction of a CBD Party".

As Arico and Salpin (2005) go on to observe

> "Under Article 22, the CBD does not affect the rights and obligations of Parties deriving from existing international agreements, except where the exercise of those rights and obligations would cause serious damage or threats to biodiversity. Since the exploitation of marine genetic resources in areas beyond national jurisdiction including those of the seabed implies value-addition, several articles of CBD could provide a basis for States to regulate bioprospecting activities of their own nationals in relation to such resources. These articles include Articles:

- 8 (d) on protection of ecosystems and species, *in situ*
- 9 (d) on the regulation and management of collection of resources
- (c) on the identification and monitoring of processes which have or likely to have significant adverse impact
- 8 (l) on the management and regulation of processes and activities having significant adverse impacts and
- 14 (a) and (c) on environmental impact assessments and exchange of information regarding activities having significant adverse impacts.

These provisions provide a basis for development of impact assessment guidelines, technical standards, monitoring activities and setting thresholds for collection and use of marine genetic resources".[34]

According to Arico and Salpin (2005) a study carried out analyzing CBD Decision II/10, was presented at the 8th meeting of the Subsidiary Body on Scientific Technical and Technological Advice (SBSTTA) of the CBD in March 2003. It outlined relevant provisions of the CBD and UNCLOS, and concluded that

> "neither the United Nations Convention on the Law of the Sea nor the Convention on Biological Diversity provides a specific legal regime for commercially-oriented activities relating to marine genetic resources on the High Seas and in the Area," and stressed the need to develop a legal regime to regulate them. A similarity between the objectives pursued by the international community both under UNCLOS and the CBD was noted, since both instruments aim at the conservation of marine biodiversity and attempt to ensure sustainable use of its components. The study stressed that while the CBD further aims at a fair and equitable sharing of the benefits arising out of the use of genetic resources, UNCLOS aims at an equitable sharing of benefits arising out of mineral resources from the Area. The following options to address bioprospecting for deep seabed genetic resources were examined: maintaining the *status quo* and leaving the exploitation of deep seabed genetic resources unregulated; applying the regime of the Area and its resources to deep seabed genetic resources, which would entail the application of the common heritage of humankind principle to deep

> seabed genetic resources as well as their management by an international body for the benefit of all, and amending the CBD to bring deep seabed genetic resources within its framework." (Arico and Salpin 2005).

However, Parties to the CBD were divided on how to address the issue of marine genetic resources beyond national jurisdiction since SBSTTA 8. COP 7 of CBD through its Decision VII/5 called for rapid action to address threats to marine biodiversity in areas beyond national jurisdiction, including in relevant international fora such as the UN General Assembly. Establishment of Marine Protected Areas beyond national jurisdiction was also called for with cooperation from all relevant international agencies and processes.[35]

In relation to deep seabed genetic resources beyond the limits of national jurisdiction, decision VIII/21 of the COP notes the biodiversity value of deep seabed genetic resources (VIII/21 paragraph 1) and recognizes the urgent need to enhance scientific research and cooperation on deep seabed genetic resources and to provide for their conservation and sustainable use (VIII/2 paragraph 2). The COP decision also emphasizes the urgent need for capacity building in developing countries relating to deep seabed biodiversity (VIII/21 paragraph 9).

Discussions under the Working Group on Access and Benefit Sharing are to cover issues of need for transparency in exchange of genetic resources and call for disclosure of origin of genetic resources in applications for intellectual property rights. Currently CBD, UNCLOS as well as other intergovernmental processes are unclear on how to address these issues.

Several studies concluded that any meaningful benefit sharing regime on deep seabed genetic resources can be effected only if such resources are brought under a regime similar to that governing the mineral resources of the Area under UNCLOS. Such an approach reflects the view taken by the G77 on the issue more than any of the other views expressed by non G77 States and other stakeholders to date. But as noted elsewhere in this paper this is by no means the only possible option for addressing the issue. The maintenance of a firm attachment to such an approach may make it very difficult for a clear resolution of the issue to be achieved. Perhaps a more flexible approach is warranted. The debate should perhaps focus on what is the best way to achieve an equitable distribution of benefits associated with bioprospecting in marine areas beyond national jurisdiction rather than automatically jumping to the conclusion that there is but one solution to the issue.

In addition to the other models mentioned above lessons can also be learned from other regional instruments focusing on protection and use of marine environments including the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) that includes focus on cooperation and protection of marine environments of the High Seas and underlying seabed and sub-soil with provision of measure for protection of species and habitats; the Noumea Convention (Convention for the Protection of the Natural Resources and Environment of the South Pacific Region) that covers seabed activities; the Mediterranean Action Plan that includes maritime areas in the High Seas, beyond the national jurisdiction of the 22 Parties to the Barcelona Convention for the protection of the marine environment and the coastal region of the Mediterranean; the Antarctic Treaty System (ATS) that includes the Antarctic Treaty, the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), the Madrid Protocol and the Convention on Regulation of Antarctic Mineral Resources Activities (CRAMRA), and the Intergovernmental Oceanographic Commission of UNESCO.[36]

In addition several non-governmental initiatives such as the InterRidge Initiative that facilitates international and multi-disciplinary research associated with mid-ocean ridges, and the Micro-Organisms Sustainable Use and Access Regulation International Code of Conduct (MOSAICC) have contributions to make to defining the ABS provisions for marine genetic resources in areas beyond national jurisdiction.[37] National activities and experience such as Canada's Endeavour Marine Protected Area, the Lucky Strike and Menez Gwen Marine Protected Area of Portugal etc. also provide some examples of national interventions to deal with issues of access to marine genetic resources with limited focus on benefit sharing.[38]

Recent Developments Relevant to Deep Sea Genetic Resources, including ABS

At a recently-held Strategic Planning Workshop on Global Ocean Issues in Marine Areas Beyond National Jurisdiction in the Context of Climate Change (Nice, France, January 23-25, 2008) held under the auspices of the Global Forum on Oceans, Coasts, and Islands and with the co-sponsorship of the Nippon Foundation, it was stressed that "[w]hile there has been substantial progress in recent years in achieving integrated governance of oceans in areas under national jurisdiction and in regional seas areas, governance of areas beyond national jurisdiction remains largely sectorally-based, fragmented, and inadequate. This means that it is difficult to address inter-connected issues (such as the impacts of human uses on the environment, multiple-use conflicts among users, and responses to climate change effects) through an integrated and ecosystem-based approach. There are, moreover, significant differences of opinion among stakeholders regarding what actions need to be taken to improve governance in marine areas beyond national jurisdiction, especially regarding the question of distribution of benefits from the uses of biodiversity in these ocean areas" (Global Forum 2008a).[39]

At the Nice Workshop, there were discussions about the usefulness of examining modes of benefit sharing which had been developed in other areas so as to inform future debates in the context of relevant fora, namely, the UN Working Group and the CBD. This was based on the consideration that providing an overview of the range of modes of benefit sharing represented a key step in the work of the Global Forum on improving governance of marine areas beyond national jurisdiction.

At the 4th Conference on Oceans, Coasts and Islands organized by the Global Forum (Hanoi, 7-11 April 2008), a number of such possible ABS models and tools were considered so as to further discussions on deep sea genetic resources. These models include: the IOC Abe-LOS Criteria and Guidelines on Transfer of Marine Technology; the ABS-Management Tool developed by the International Institute for Sustainable Development; The World Intellectual Property Organization contracts database; the CBD ABS case studies; the UNU-IAS Information Resources on Biological Prospecting; the OECD study on Valuation and Exploitation of Intellectual Property; the OECD study on Research Use of Patentable Knowledge: A Review; and the Call of the Earth Llamado de la Tierra and UNU-IAS publication on Pacific Genes and Life Patents, Pacific Experiences and Analysis of the Commodification and Ownership of Life – among others.[40]

At the Hanoi Conference, the Co-chairs of the Global Forum Working Group on Governance of Marine Ecosystems and Uses in Areas Beyond the Limits of National Jurisdiction produced a report for consideration by the UN Working Group at its second meeting (New

York, 28 April – 2 May 2008). The report refers to current discussions in relation to access to genetic resources in areas beyond national jurisdiction and their potential for applications such as pharmaceuticals and industrial processes, as well as with regard to the sharing of the benefits arising from their utilization. The report suggests that these discussions should continue in an appropriate forum. In particular, the United Nations General Assembly *Ad Hoc* Open-ended Informal Working Group should be institutionalized as a regular mechanism that provides the forum to pursue discussions and make recommendations on issues related to marine biodiversity in areas beyond national jurisdiction, including the equitable and efficient utilization as well as the conservation of on marine genetic resources. Access and benefit-sharing, as well as capacity-building, should also be an important element of these discussions, and appropriate models of trusts that would operate on the basis of users' rights should be identified.[41]

Although moderate in length and scope, the discussions on genetic resources at the second meeting of the UN Working Group (New York, 28 April-2 May 2008) largely confirmed the directions of work suggested by the Global Forum WorkingGroup.

Future Options for ABS Discussions related to Marine Biodiversity

Given the need to conserve marine biodiversity, sustainably use the resources and share benefits of such use, it is important to understand the nature of the problem and this can only be achieved with further detailed study of these issues. While the CBD, UNCLOS, UNGA, ATS and others deal with issues of marine biodiversity they have so far had limited progress in linking up with each other to address issues of conservation, use and access issues for marine genetic resources. Political and administrative divisions continue to exist within each of these processes which in part appear to fail to consider a forward-looking agenda for sustainable use and ABS issues related to marine biodiversity. It is therefore important to consider the following as possible related questions or issues that need to be considered for discussion under all the above fora:

1. Discussions under CBD, UNCLOS and the related international forums need to be based on clear understanding of legal and compliance issues as well as national capacities to implement the

provisions. As such further studies are required on the capacity of all states on this issue.

2. Bioprospecting in marine environments is an emerging area of research for many countries. Environmental impacts of such actions are poorly assessed. Quantitative data and evidence to show the optimal levels of harvesting marine genetic resources is either lacking or purely anecdotal. In the absence of development of assessment tools on short and long term impacts of sourcing marine biodiversity it will be difficult for countries to assess the potential use of marine biodiversity for bioprospecting purposes. The biodiversity impact assessment and environmental impact assessment tools developed under the CBD may need to be extended for application and use in marine environments. A first step towards this goal might be a detailed study of the potential and actual impacts of bioprospecting in marine areas beyond national jurisdiction and their connections if any with other extractive uses of ocean resources.
3. Though several studies have indicated the growing commercial interests of using marine biodiversity, the economic potential of marine biological resources is yet to be ascertained. Valuation of marine biodiversity is therefore needed in order to assess the size of commercial and related markets for these resources. Simply put now is the time for a "Stern Review" for the Oceans.
4. Discussions under the Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable utilisation of marine biological resources beyond areas of national jurisdiction established by the UN General Assembly need to consider linkages with discussions under the CBD on development of an international regime on ABS. There have been some initial studies on possible options for ABS but there is limited analysis of such options. Scientific cooperation and technology transfer form the core of such options.[42] These should be discussed in light of the commercial interests and confidentiality terms associated with use of marine biodiversity for commercial purposes.
5. A critical issue relating to benefit sharing is the interaction of any benefit sharing regime with national and international patent systems. A detailed study of how existing patent regimes interact with other relevant sources of law and policy is required. A second aspect of such a study should consider possible modalities for

interaction between patent regimes and each of the possible options for benefit sharing.

6. The nature and scale of partnerships between industry and scientific research institutions is unclear. Again what information that is available is largely anecdotal. A detailed study on the nature and extent of these partnerships, together with a study of the legal arrangements and modalities of operation of existing partnerships would help inform on-going debate on this issue, especially having regard to the close link between so called pure [sic] marine scientific research and bioprospecting.
7. Discussions both within UN and outside need to address the need for establishing an institution or process or modify an existing institution or process with a mandate to adopt conservation measures, authorise and receive access requests (if closer examination of possible options suggest this is desirable), and possibly negotiate benefit sharing arrangements, deal with technology transfer and information exchange and feed into various national, regional and international fora.

The need for such institutions or processes will however very much be determined by what form of regulation if any the international community deems desirable. There should not be regulation just for regulations sake, but instead future consideration of options should be focussed on the desired outcomes which in turn will point the way to suitable options. It is absolutely fundamental to the success of any future regime that it is outcomes focussed and is not to bureaucratic. The last thing we need is for a future ABS regime for marine areas beyond national jurisdiction to effectively put a brake on future scientific and commercial advances. Most importantly any future regime must be built on the key pillars of sustainable use and conservation of biodiversity that underlie the CBD. These principles are fundamental to the future of marine biodiversity in areas beyond national jurisdiction for present and future generations.

Conclusions

Issues identified and discussed in this paper are a clear result of limited and sometimes conflicting interests of international negotiation processes. Some of the issues that are emerging seem to stem from the advances made in scientific and technological fields that necessitate global and regional agreements to be responsive to such changing and emerging needs of countries and institutions.

It is of critical importance that international negotiations under various institutions should be based on on-the-ground realities in terms of governance options, capacities of stakeholders involved, resources and timelines available to effect change and decision making based on a holistic understanding of the issues rather than sectoral opinions. It is hoped that all the stakeholders who are either parties to the discussions or who will be affected by the decisions will understand the inter-linkages on the main dimensions of ABS identified in this paper when making decisions and drawing up protocols and action plans to conserve, sustainably use and share the benefits of genetic resources both within and beyond areas of national jurisdiction.

Endnotes

[1] Article 16 on Access to and Transfer of Technology states that each Contracting Party undertakes subject to the provisions of the Article to provide and/or facilitate access for and transfer to other Contracting Parties of technologies that are relevant to the conservation and sustainable use of biological diversity or make use of genetic resources and do not cause significant damage to the environment. Access to and transfer of technology to developing countries shall be provided and/or facilitated under fair and most favorable terms, including on concessional and preferential terms where mutually agreed. In the case of technology subject to patents and other intellectual property rights, such access and transfer shall be provided on terms which recognize and are consistent with the adequate and effective protection of intellectual property rights. Each Contracting Party shall take legislative, administrative or policy measures with the aim that Contracting Parties, in particular those that are developing countries, which provide genetic resources are provided access to and transfer of technology which makes use of those resources, on mutually agreed terms, including technology protected by patents and other intellectual property rights, where necessary, through relevant CBD provisions (Articles 20 and 21) and in accordance with international law. Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, with the aim that the private sector facilitates access to, joint development and transfer of technology for the benefit of both governmental institutions and the private sector of developing countries. Article 19 on Handling of Biotechnology and Distribution of its Benefits states that each Contracting Party shall take legislative, administrative or policy measures, as appropriate, to provide for the effective participation in biotechnological research activities by those Contracting Parties, especially developing countries, which provide the genetic resources for such research, and where feasible in such Contracting Parties. Each Contracting Party shall take all practicable measures to promote and advance priority access on a fair and equitable basis by Contracting Parties, especially developing countries, to the results and benefits arising from biotechnologies based upon genetic resources provided by those Contracting Parties. Such access shall be on mutually agreed terms.

[2] Vierros et. al (2007).

[3] *ibid.*

[4] Leary (2007).

[5] Vierros et. al (2007).

[6] Leary (2008a).

[7] *ibid.*

[8] Leary (2008b).

[9] Leary (2008b).

[10] Vierros et. al (2007).

[11] Vierros et. al (2007).

[12] Ruth (2006).

[13] UNEP (2007).

[14] Glowka (1996).

[15] Glowka (1996).

[16] Leary (2007).

[17] *ibid.*

[18] *ibid.*

[19] Leary (2007).

[20] Leary (2007).

[21] Arico (2008).

[22] Leary (2007).

[23] *ibid.*

[24] Leary (2007)..

[25] Leary (2007).

[26] *ibid.*

[27] *ibid.*

[28] Leary (2007).

[29] Leary (2007).

[30] Leary (2007).

[31] *ibid.*

[32] *ibid.*

[33] *ibid.*

[34] Arico and Salpin (2005).

[35] Arico and Salpin (2005).

[36] See Leary (2007); and Arico and Salpin (2005).

[37] Arico and Salpin (2005).

[38] Leary (2007), See also Arico and Salpin (2005).

[39] Participants in the Nice Workshop identified a variety of options for considering the special issues involved in the management of marine genetic resources, as follows:

- Identify: a) potential benefits from research and commercialization of marine genetic resources in areas beyond national jurisdiction; b) options for benefit sharing, including learning from case studies on best practices; c) modalities for promoting equitable use;
- Promote continued and focused marine scientific research;
- Identify means of data banking, knowledge management and sharing i.e. the biotech industry should provide information on where the samples of organisms identified to be of medicinal, industrial, other value, have been collected, for management and conservation purposes;
- Involve the biotech industry in the planning process;
- Facilitate government-to-government discussions, especially between developed and developing nations;
- Identify and assess management options, which are potentially applicable in addressing the threats to marine genetic resources, including codes of conduct, permits and environmental impact assessment, area-based management, and ecosystem-based management, for adoption across sectors and regions;
- Carry out economic analysis; analysis of comparative advantage;
- Form partnerships and formal agreements of collaboration, including memoranda of understanding.

[40] Vierros and Wells (unpublished).

[41] Global Forum (2008b).

[42] See for example Intergovernmental Oceanographic Commission, 2005.

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Access and Benefit Sharing and the Biological Diversity Act of India: A Progress Report

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Abstract: Biological Diversity Act, 2002 was enacted in the parliament of India on 5th February 2003 and to implement the above act the National Biodiversity Authority was established in September 2003. Following this the Biological Diversity Rules 2004 were notified as well as various sections of the BD Act simultaneously. For effective functioning of the National Biodiversity Authority the Regulation/Guidelines /notifications were being prepared and notified based on priority. Since the BD Act is in force in India, the application for Access for Bioresources and associated Traditional Knowledge (for research and/or commercial use), Transfer of Research Results (Technology), approval for Patent (IPR) applications and Third Party Transfer of Bioresources were received regularly and approved by the National Biodiversity Authority in accordance with the BD Act. The nitty-gritty of the process of the approval of application for access of bioresources, the criteria for benefit sharing and the recent developments in the National Biodiversity Authority in connection with access and benefit sharing are shared in this paper for transparency in the ABS process.

Keywords: ABS India, Biological Diversity Act, 2002 progress till 2008.

Introduction

India is one of the 12 mega biodiversity countries of the world as well as one of the mega-diversity countries. Demographically, it is the second-largest populated country in the world and a majority of its population still directly depends on biological resources for their livelihood. With only 2.5 per cent of the total land area, India accounts for 8 per cent of the recorded species of the world which includes countless millions of races, subspecies and local variants of species and the ecological

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processes. India is very rich in terms of biological diversity due to its unique bio-geographic location, diversified climatic conditions and enormous eco-diversity and geo-diversity. India embraces three major biological realms, viz. Indo-Malayan, Eurasian and Afro-tropical and is adorned with 10 bio-geographic zones and 26 biotic provinces.[1]

Plant Diversity

About 850+ species of bacteria, 14,500+ species of fungi 6,500+ species of algae and 17,500+ species of flowering plants are reported from India till today[2]. At National level, the information on flowering plants has been documented in 24 Fascicles by the Botanical Survey of India in addition to eight volumes covering general aspects of flora of India, such as physiography; geology; climate; botanical history; phyto-geographical divisions; endemism; centers of diversity and phyto-geographical affinities; exotics; ethno-botanical, medicinal and plants of other economic value; plant based industries; wild relatives of cultivated plants; endangered plants, habitats and their conservation; protected area network; botanic gardens and the statistical analysis of the flora have been published.

Faunal Diversity

So far 89,451 species of fauna have been identified from India and insects alone account for 59,353 species. Amongst invertebrates, parasitic forms, Meiofauna and Soil Fauna (Annelida) exhibit a very high degree of endemism at species level. Overall, 34.90 per cent of insect species are endemic to the Indian region and more than 40 per cent of Indian leech, freshwater sponges and molluscs also show endemism. Among vertebrates, highest degree of endemism at species level is seen in Amphibia followed by Reptilia, Aves, Mammalia and Pisces.[3] Fisheries in India play an important socio-economic role. More than six million fishermen and fish farmers in India depend on fisheries and aquaculture for their livelihood. The harvestable potential of marine fishery resources in the Indian Exclusive Economic Zone has been estimated at about 3.9234 mt. A total fish production of 8.09 million tonnes (3.26 million tonnes from the marine sector and 4.83 million tonnes from the inland sector) had been achieved at the end of the 2007.

Crop Diversity

India's preponderance of native tribal and ethnic groups has contributed significantly in the conservation and diversification of biodiversity. Its cultural and ethnic diversity includes over 550 tribal communities of 227 ethnic groups spread over 5,000 villages. These people have traditionally protected patches of forests in the form of sacred groves dedicated to deities and more than 50,000 sacred groves have so far been reported from various parts of the country which harbour several species of flora and fauna. India holds a prominent position among the eight vavilovian centres of origin of cultivated plants, which is the geographic region where crops exhibit maximum diversity in terms of number of races and botanical varieties.[4] In India, rice landrace variability exists both in indigenous crops as well as those introduced from other parts of the world. Today, about 166 crop species and well over 324 species of wild relatives of crop plants are recognized and utilized for food production. Wild edible plants account for nearly 1000 species serving various purposes: 145 as roots/tubers, 526 as leafy vegetables/greens, 101 for buds/flower, 647 for fruits and 18 for seeds and nuts.

Moreover, India has rich tradition of conserving nature and natural resources. Worship of trees, forests, rivers, ponds, mountains and association of animals and birds with gods and goddesses have contributed immensely to their conservation. Various traditional systems of *in-situ* conservation of natural resources have been organised and institutionalised. Therefore, a great challenge exists for India to conserve its rich biodiversity while ensuring economical and ecological security.

Multilateral Environmental Agreements on Biological Diversity and India's Responses

India has been playing a major role in the implementation of global, international, regional and national policies and programs related to environment, biodiversity, trade and intellectual property rights. Biological diversity and associated traditional knowledge are two important areas of focus for India, with links to sustainable development. With such a focus, India is Party to the World Heritage Convention (1972), Convention on International Trade in Endangered Species of Flora and Fauna (CITES) (1975), Ramsar Convention on Wetlands (1975), Convention on Biological Diversity (1992), Agenda 21 (1992), UN Framework Convention on Climate Changes (1992), UN Convention to Combat Desertification (1994), the Trade Related Intellectual Property Rights (WTO-TRIPs) 1994, Cartagena Protocol for Biosafety to CBD (2000), FAO International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2001) and others.[5] CBD is the most comprehensive legal instrument that addresses the issues of access to genetic resources and benefit sharing with explicit links to issues related to traditional knowledge associated with genetic resources. Consequent to the ratification of CBD by India on 18th February 1994 and in pursuance of the Conference of Parties (CoP) decisions of CBD that followed, the Ministry of Environment and Forests - the national focal point of CBD, has taken steps to implement the CBD provisions by promulgating the Biological Diversity Act, 2002 (NBA) in Parliament of India. Recognizing urgent need to develop human resources, capabilities and legal and public policy to enable countries rich in Biodiversity to take an active part in the new economy associated with the use of Biological Diversity, a set of rules to implement the NBA were developed in 2004. India continued to play a crucial rule in furthering global debates on ABS in several international fora including the World Intellectual Property Organisation (WIPO), the Trade Related Intellectual Property Rights (TRIPS) council and others. India also is the founding member of the Like-Minded Mega biodiverse Countries (LMMC) group that worked actively towards a decision to develop an international regime on ABS. In doing so, India continues to insist that the regime must be "legally-binding" for the effective implementation of the ABS requirements enunciated by the CBD.

Biological Diversity Act, Access and Benefit sharing

The Biological Diversity Act, 2002 India, primarily addresses the issues concerning access to genetic resources and associated knowledge by foreign individuals, institutions or companies, and equitable sharing of benefits arising out of the use of these resources and associated knowledge by the country and its people.[6] The Act governs Access and Benefit Sharing (ABS) through a three tier system, National Biodiversity Authority (NBA), State Biodiversity Board (SBB) and Biodiversity Management Committees (BMC). The NBA deals with matters relating to requests for access to bioresources and associated traditional knowledge by foreign individuals, institutions or companies, and all matters relating to transfer of results of research to any foreigner; imposition of terms and conditions to secure equitable sharing of benefits, establish sovereign rights over the bioresources of India and approval for seeking any form of Intellectual Property Rights (IPRs) in or outside India for an invention based on research or information pertaining to a biological resource and associated traditional knowledge obtained from India. SBBs deal with matters relating to access to bioresources by Indians for commercial purposes and restrict any activity which violates the objectives of conservation, sustainable use and equitable sharing of benefits. The mandate of the BMCs is conservation, sustainable use, documentation of biodiversity and chronicling of knowledge relating to biodiversity. BMCs shall be consulted by the National Biodiversity Authority and State Biodiversity Boards on matters relating to use of biological resources and associated knowledge within their jurisdiction. In order to safeguard the interests of the local people and to allow research by Indian citizens within the country, free access to biological resources for use within India for any purpose other than commercial use for Indian people has been given to *vaid* and *hakims* (= traditional physicians) and other citizens.

Provisions for setting up of Biodiversity Funds at Central, State and Local levels are provided (Sections 27, 32 and 42) in the Biological Diversity Act, 2002. The monetary benefits, received as fees and royalties for approvals by National Biodiversity Authority is deposited in National Biodiversity Fund and used for conservation and development of areas from where resources have been accessed.

National Biodiversity Authority

The Biological Diversity Act of India, 2002 and the Biological Diversity Rules, 2004, is implemented by the NBA established by the Government of India under Section 8. The National Biodiversity Authority also performs functions such as laying down the procedures and guidelines to govern the activities such as access and benefit sharing and Intellectual Property Rights, in accordance with the Article 8 (j) of the CBD. The authority also coordinates the ABS activities of the SBB and BMC by providing them with technical assistance and guidance. NBA advises the government on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of benefits arising out of the utilization of biological resources, select and notify the areas of biodiversity importance as biodiversity heritage sites under this act and perform other functions as may be necessary to carry out the provisions of the act. The NBA on behalf of the Government of India takes measures to protect the biological diversity of the country as well as oppose the grant of intellectual property rights to any foreign country on any biological resource obtained from India or knowledge associated with such biological resource.

The establishment of the ABS provisions and their effective implementation in the territorial jurisdiction of India is dealt with in the Biological Diversity Act 2002 (Sections 3, 4, 6) and in the Biological Diversity Rules 2004 (Rule 14-20). This act provides for regulated access to biological and genetic resources by bonafide end-users for different purposes, including scientific research, commercial uses, biosurvey, bio-utilization, conservation and other sustainable uses, etc. The overall implementation of the Act is governed by three functional bodies viz. NBA, SBB, and BMC. NBA is the national competent authority to discharge all decisions pertaining to ABS, including prior informed consent process, approval for access and transfer of biological resources and scientific research results and technologies to foreign citizens, companies and non-resident Indians (NRIs), prior approval for applying for IPRs based on biological resources or traditional knowledge obtained from India, fixing criteria for benefit sharing, approval of third – party transfer of accessed biological resources and traditional knowledge, and several other matters related to ABS.

Access to Biological Resources and Associated Traditional Knowledge under the National Biodiversity Act

The Act stipulates norms for access to biological resources and traditional knowledge based on three ways:

(i) Access to biological resources and traditional knowledge to foreign citizens, companies and NRIs based on 'prior approval of NBA' (Section 3, 4, 6 of the Act and Rule 14-20).

(ii) Access permits to Indian citizens, companies, associations and other organizations registered in India on the basis of 'prior intimation to the State Biodiversity Board' concerned (Section 7 of the Act).

(iii) Exemption of prior approval or intimation for local people and communities, including growers and cultivators of biodiversity, and *vaids* and *hakims,* practicing indigenous medicines (Section 7 of the Act).

The key procedures to be followed for access to biological resources and traditional knowledge are dealt with under Rule 14 of the Biodiversity Rules 2004. These provisions are laid down to ensure effective, efficient and transparent access procedures through written agreements and applications in prescribed formats. Applicants seeking access to biological resources and traditional knowledge are required to submit an application in FORM I[7] along with an application fee of INR 10,000/-.[8] Once the application is approved for access, an agreement has to be signed by the applicant for access of bioresources.

The NBA through appropriate consultation mechanisms, approve the applications and communicates its decision to grant access or otherwise to the applicant within a period of six months from the date of receipt of the application. The Authority is required to communicate the grant of access to the applicant in the form of a written agreement duly signed by an authorized official of the Authority and the applicant. The rule 14 also stipulates the Authority to provide reasons in writing in cases of rejection of an application and give reasonable opportunity to the applicant to appeal. The Authority shall publicise the approval granted through print or electronic media and also shall monitor the compliance of the conditions agreed to at the time of accordance of approval of grant for access, by the applicant.[9] The access procedures are only regulatory in nature, not prohibitive in any manner to any applicant irrespective of their nationality, affiliations, origin, etc. Since inception, NBA has received more than 260+ applications for access, transfer of bioresources and patent protection. Fee has been paid to National Biodiversity Fund as per the BD Rule 2004 depending upon the type of applications.[10]

Revocation of access or approval

Revocation of access or approval granted to an applicant will be done only on the basis of any complaint or *suo moto* under the following conditions: (i) violation of the provisions of the Act or conditions on which the approval was granted, (ii) non-compliance of the terms of the agreement, (iii) failure to comply with any of the condition of access granted and (iv) on account of overriding public interest or for protection of environment and conservation of biodiversity (Rule 15, Sub rule 1). After having withdrawn the access permit, the Authority is required to send an order of revocation to the concerned Biodiversity Management Committee and the State Biodiversity Board for prohibiting the access and to assess the damage, if any, caused and steps to recover the damages (Rule 15, Sub rule 2).[11]

Restrictions for access to biological resources

The Act imposes certain restrictions on request related to access to biological resources and traditional knowledge if the request is on: (i) endangered taxa, (ii) endemic and rare taxa, (iii) likely adverse effects on the livelihood of the local people, (iv) adverse and irrecoverable environmental impact, (v) cause genetic erosion or affect ecosystem function and (vi) purpose contrary to national interests and other related international agreements to which India is party (Rule 16, Sub rule 1).[12]

Procedure for prior approval of transfer of research results

The Act does not permit any person to transfer the results of any research relating to biological resources obtained form India for monetary consideration to foreign nationals, companies or non resident Indians (NRIs) without the prior approval of the Authority (Section 4). Approval for such transfers shall be done on the basis of an application to authority in FORM II[13] along with the payment of an application fee of INR 5000/-. The Authority within a period of three months from the receipt of an application shall take a decision on it. As in the case of access permits the Authority shall communicate the approval for transfer of research results to the applicant in the form of a written agreement duly signed by an authorized official and the applicant. The authority shall communicate the reasons in case a request for transfer of research results is not granted and shall give reasonable opportunity and time to the applicant for an appeal, if any (Rule 17, Sub rules 1-6).

Procedure for Prior Approval before Applying for IPR: (Section 6 of the Act and Rule 18, Sub rules 1-6)

All the conditions for granting approval for transfer of research results shall be applicable to any person desirous of applying for a patent or any other intellectual property rights, based on biological resources and knowledge obtained form India. The format for making such applications (FORM III)[14] is annexed to the Biodiversity Rules 2003.

Procedures for Third Party Transfer of Accessed Biological Resources or Knowledge: (Rule 19, Sub rules 1-6)

The Act permits transfer of accessed biological resources or associated knowledge to a third party on the basis of the prior approval of the Authority through a process of submitting an application in FORM IV[15] along with the payment of an application fee of INR 10,000/-. The other procedures remain the same as those stipulated for access to biological resources and traditional knowledge under Rule 14

Criteria for Benefit Sharing

The Act, according to Section 21 and Rule 20 of the Biodiversity Rules,[16] insists upon including appropriate benefit sharing provisions in the access agreement and mutually agreed terms related to access and transfer of biological resources or knowledge occurring in or obtained from India for commercial use, bio-survey, bio-utilization or any other monetary purposes. The National Biodiversity Authority is in the process of developing a guideline based on the provision of the Biological Diversity Act, 2002 and the same will be notified with the specific details of benefit sharing formula in an official gazette on a case-to-case basis. While granting approvals for access, NBA will impose terms and conditions so as to secure equitable sharing of benefits. These benefits *inter alia* include:

a) grant of joint ownership of intellectual property rights to the National Biodiversity Authority, or where benefit claimers are identified, to such benefit claimers;
b) transfer of technology;
c) location of production, research and development units in such areas which will facilitate better living standards to the benefit claimers;
d) association of Indian scientists, benefit claimers and the local people with research and development in biological resources and bio-survey and bioutilization;
e) setting up of venture capital fund for aiding the cause of benefit claimers;
f) payment of monetary compensation and other non-monetary benefits to the benefit claimers as the National Biodiversity Authority may deem fit.

The Biological Diversity Act provides for setting up of biodiversity funds at national, state and local levels. Benefits will be given directly to individuals or group of individuals only in cases where biological resources or associated knowledge are accessed directly through them. In all other cases, monetary benefits will be deposited in the Biodiversity Fund which in turn is used for the conservation and development of biological resources and socio-economic development of areas from where resources have been accessed. The time frame and quantum of benefits to be shared shall be decided on case-to-case based on mutually agreed terms between the applicant, authority, local bodies, and other relevant stakeholders, including local and indigenous communities.

One of the suggested mechanisms for benefit sharing includes direct payment to persons or group of individuals through district administration, if the biological material or knowledge is accessed from specific individuals or organizations. In cases where such individuals or organizations could not be identified, the monetary benefits shall be paid to the National Biodiversity Fund. Five percent of the benefits shall be earmarked for the Authority or State Biodiversity Board towards the administrative service charges.

The ABS procedures stipulated under the Biodiversity Act, 2002 are in line with the provisions of international laws and policies, particularly CBD and the Bonn Guidelines. The entire procedures as described in the Act can contribute substantially to facilitate an international regime of ABS on genetic resources and traditional knowledge.

Some Recent Developments under the NBA

The implementation of different sections of the Biological Diversity Act is the major task of NBA. Guidelines on Collaborative Research Projects (under Section 5 of the BD Act) involving transfer or exchange of biological resources or information relating thereto between institutions, including government sponsored institutions of India and such institutions in other countries has been prepared and notified.[17] Establishment of Designated National Repository (DNR) (Section 39) is an essential part of the infrastructure for biodiversity conservation. DNR consists of service providers and repositories of preserved specimen consisting of all fauna, herbarium (dried plant material for research), the living cells, genomes of organism, and information relating to heredity and the functions of biological systems. DNRs also contain collections of culturable organisms (e.g. micro-organisms, plant, animal and human cells), replicable parts of these (e.g. genomes, plasmids, viruses, cDNAs), viable but not yet culturable organisms, cells and tissues, as well as databases containing molecular, physiological and structural information relevant to these collections and related bioinformatics." National Biodiversity Authority India has prepared guidelines on Designated National Repository and it is in the process of notification. The other guidelines such as access to bioresources or associated knowledge for research or for commercial purpose by foreigners (Section 3 of the BD Act) and determination of equitable benefit sharing arising out of the use of accessed biological resources, their by-products, innovations and practices associated with their use and applications and knowledge (Section 21 of the BD Act), transfer of results of any research relating to any biological resources occurring in or obtained from India for further research or for commercialization (Section 4 of BD Act), intellectual property rights of invention based on any research or information on a biological resources obtained from India (Section 6 of the BD Act), biological resources normally traded as commodities (Section 40 of the BD Act), and areas of importance as Biodiversity Heritage sites (Section 37) are in the process of notification under the Act.

Conclusions

India's National Biodiversity Act and Rules form the core of India's commitment to implementing the CBD. Focus of the Act is broader than presented in this article. However, implementation of the Act requires human resource, institutional, financial capacities that still need to be strengthened along with much needed increase in awareness of public at local level in order to make the Act relevant and useful for conservation and development.

Efforts are underway to ensure the experience of India's implementation can be adequately reflected in the global negotiations on development of the international regime. In this regard, we welcome opportunities to share our experiences on development and implementation of the Act and Rules to all those interested. While national actions are based on national priorities, global influences they can make are enormous.

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The International ABS Regime Negotiations: A Business Opportunity?

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Abstract: The growing trend in the pharmaceutical industry for developing plant based drugs triggered a major global debate on access to genetic resources and sharing of benefits from these initiatives. The World Summit for Sustainable Development (2002) has shifted the global debate from Bonn Guidelines to CBD where negotiations are on at he Ad Hoc Open-ended Working Group on Access and Benefit Sharing. There are several important challenges before this group on which lot of clarity is required.

Keywords: genetic resources, access and benefit sharing (ABS), biotechnology, Convention on Biological Diversity (CBD), biotechnology, Bonn Guidelines

Recent expert statements suggest that biotechnology is replacing pharmaceuticals as the driver for commercial research on genetic resources and, further, that this trend could accelerate in the future.[1]

What is indisputably clear at this moment is the fact that genetic resources continue to fuel important process and product development in the biotechnology sector worldwide. Indeed, the potential value of genetic resources has not escaped the attention of some governments and companies. The search for new compounds in the wild, "bioprospecting" as some define it, could be worth US$ 500 million by 2050.[2]

As the search for commercially promising genetic resources and their derivatives continues, the policy and regulatory environments

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around access and benefit-sharing of genetic resources (ABS) are in a state of flux – with governments moving to protect their national interests in light of their international obligations under various Conventions, Agreements and processes. Much of the debate and energy on ABS is centered in the UN Convention on Biological Diversity (CBD).

The main provisions on ABS under the Convention are set out in Article 15. States have sovereign rights over their genetic resources, and so national governments have the authority to determine how material is accessed, but should facilitate access for environmentally-sound uses. Access should be granted only with the prior informed consent of providers and requires mutually agreed terms between providers and users. Research should be carried out with the full participation of, or carried out in, provider countries, and benefits from use should be shared fairly and equitably between the users and providers.

As with the rest of the CBD, individual governments decide how to interpret and implement the ABS provisions at the national level, as each country has its own legal systems, national authorities and stakeholders. Consequently, there is a wide variation in how countries are implementing ABS (and, it should be noted, potentially leading to confusion for both providers and users of genetic resources). To address this uncertainty, in part, a working group on ABS was set up in 2001 under the CBD, and in 2002 the Convention's Conference of the Parties adopted the voluntary Bonn Guidelines on access and benefit-sharing and the fair and equitable sharing of benefits arising from their utilisation. This tool provides guidance for governments and other stakeholders (such as institutions or companies) on the development of domestic laws and policies and steps in the negotiation of ABS contracts. The Guidelines provide some clarification on prior informed consent (including advice on a workable system, and information users should provide) and mutually agreed terms (what should be included, and examples of typical terms). The Bonn Guidelines also emphasise the need for ABS National Focal Points and Competent National Authorities to provide information on national procedures for access and benefit-sharing.

While a number of countries and companies are now using the Bonn Guidelines (and they appear as relevant today as when adopted in 2002), a new international regime on ABS under the CBD was called for in Johannesburg at the World Summit for Sustainable Development in 2002. In response, negotiations on this regime are being out in the Ad Hoc Open-ended Working Group on ABS, which has a deadline of 2010 to complete its work on the elaboration and negotiation of the regime.

Myriad challenges are confronted and are to be resolved by the International Regime negotiators. Some of these challenges are highly complex and technical in nature, while others are largely political, but no less vexing. The following un-exhaustive list of questions will need answers in order to complete negotiations on the regime. What should the objectives of the international regime be? Should the Regime embrace both mandatory and voluntary measures? Are industry sectoral approaches tenable within the international regime? Should compliance be the principal focus of the regime? If and how should negotiators deal with traditional knowledge related to genetic resources? Is ABS ultimately about capacity needs and, if so, what is the role of the private sector in this regard? How to deal with intellectual property rights issues?

One of the greatest hurdles to be overcome in the international ABS talks is, in plain words, lack of awareness on the social, economic, legal and policy links within ABS. Upon our election as Co-chairs of the ABS Working Group in 2006 by the Conference of the Parities to the Convention on Biological Diversity in Curitiba, Brazil, we identified awareness building among the keys to "unlocking" the international regime talks. Awareness must be built within and amongst countries, and involve political leaders, government officials, stakeholders, indigenous and local communities and the general public. Industry engagement, including importantly the biotechnology sector, is a critical – not only in terms of improving understanding of national interest, but equally in terms of identifying practical options and concrete solutions to existing and proposed ABS-related policies.

In the past two years we have noted an encouraging trend toward greater industry involvement in the meetings of the ABS Working Group. Not only does the number of active industry participants appear to be increasing, industry representatives have risen to the universal challenge from the Co-chairs to the Working Group to engage concretely and constructively in the debate.

This is an important and encouraging step forward. But it is insufficient. The biotechnology sector, like other industry sectors, must further engage at both the national and international levels. As we all know, good policy ideas and solutions, more often than not are first generated at home.

In the longer term — beyond the participation of the biotechnology and other industrial sectors in the ABS negotiations themselves – are the role and core responsibilities of the private sector in implementing the international regime. Implementation will need to take place as a large-scale exercise with business acting in partnership with the public sector and the non-profit sector, and include investment in areas such as: (1) investing in R&D, often with public funding partnerships, in food security, public health, and the conservation of biodiversity; (2) promoting biotechnologies based on genetic resources and their adaptation to distinct local environments. This is an approach that recognizes the increasing role of businesses as repositories of the most advanced (bio) technologies and the most sophisticated management methods for large-scale influence in the fair and equitable distribution of benefits arising out of the environmentally sound use of genetic resources.

We continue to urge the biotechnology sector to further engage in ABS domestic and global ABS policymaking, both in the development of policy and rules and in their implementation. Biotechnology businesses have a critical role to play in ABS, both now and in the future.

The core issue in relation to ABS is the need for clarity in terms of do's and don't's for both providers and users of genetic resources. Unless this clarity is there, conservation actions will suffer with limited use of genetic resources by perspective users. With limited or no access to genetic resources, all debates on ABS are bound to yield no results.

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Making Access and Benefit Sharing Regime Equitable to Women

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Abstract: Gender is a factor that determines access to resources and benefit sharing. Due to gender inequity, women could be unfairly treated in the distribution and use of resources from biodiversity and genetic research. This is true for both the indigenous and non indigenous women particularly those who are poor. An ABS regime must recognize and address this iniquitous situation for women to ensure that they have a fair share in the benefits accruing from research and use of traditional knowledge. Mainstreaming gender in ABS regimes at the international and national levels is the strategy to achieve this objective. Policies and processes that address the special situation of women are needed for the implementation of any ABS regime so that women can truly benefit from any progressive governance on access and benefit sharing.

Keywords: Gender Equity, Gender Lens, Gender Mainstreaming, Access and Benefit Sharing

Introduction

The Convention on Biological Diversity (CBD) brought a global focus on the governance of genetic resources by having access to these resources and benefit sharing as one of its founding principles. The major players in this debate are the users and providers of genetic resources where developing countries (mostly providers of genetic resources) have formed solidarity among themselves to focus the discussions on benefit sharing and the prevention of misappropriation of biodiversity resources.[1]

This position taken by developing countries is called for given that for a long time, many corporations and research institutions based mainly in developed countries have sometimes taken undue advantage of their dominance in the global liberalized economy in the exploitation and use of biodiversity resources of developing countries. These are exemplified in products such as medicines and food derived from these resources that are inaccessible to many of the people in poor nations.

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Genetic materials and traditional knowledge that were taken without the prior consent of communities that hold these resources also abound in the debates.[2]

This iniquitous state of affairs has been complained about by communities and civil society groups which are concerned not only with the unfairness that is obtaining but also with the threat to the sustainability of the environment. Among these are organizations of indigenous peoples who are among the most directly affected by corporate encroachments into their ancestral domain where the remaining forests are still found.[3]

To redress this imbalance, more attention has been given recently by international bodies (e.g. the UN) to the participation of national governments and of local communities in the protection and sustainable use of biodiversity resources. This is seen for instance in various international declarations and bioethics guidelines that seek to ensure the free and prior informed consent of affected communities as well as their fair share in the benefits that accrue from research and product development.[4]

However, there has not been as much attention to the gender question in such discussions compared to the attention on inequities between rich and poor countries.[5]

This paper argues that gender should be mainstreamed in an international and even in national ABS regimes for both human and nonhuman genetic resources. No ABS governance can be truly fair if it fails to ensure the protection of women's rights in ABS arrangements. The subordinated and discriminated situation of women the world over makes it easy to overlook their interests in ABS negotiation and decision making. The paper ends with recommendations for ways of making ABS governance equitable to women.

Conceptual Clarification

Before proceeding to discuss the need and role for gender to be considered in ABS debates, let us clarify the key concepts used in this paper. These are: (a) gender; (b) gender equity; (c) gender mainstreaming; and (d) gender lens.

Gender refers to roles, status and identities constructed by society that impact the allocation of power, entitlements, opportunities and prestige between men and women.[6] *Gender equity* means fairness and justice in the distribution of benefits and responsibility between men and women. The advocacy for gender equity results from a recognition of the differences in power between men and women that determine their well being and development thus the need to rectify the imbalances between the sexes.[7] To promote gender equity does not mean to "invert inequalities"[8] or to make women dominate men but to correct historical and structural disadvantages and create a just society for all.

Mainstreaming gender in ABS governance is examining the implications for women of the policies, processes and structures that will be put up and ensuring that the interest of women are integrated in the governing system.

Mainstreaming gender in ABS governance is the logical step to take when there is the application of the gender lens in examining issues of access and benefit sharing. *Gender lens* is a perspective that considers gender to be a fundamental factor of social life since it creates imbalances in power, access to and control over resources between men and women as a consequence of gendered structures, processes and systems. This is a holistic perspective because it recognizes the interconnectedness of gender with other structures of inequity such as poverty and ethnicity in all levels of social life.

Why should Gender be Mainstreamed in ABS Regime

Gender issues are issues that burden the majority population of the world – the women. Why are gender issues primarily women issues? It is because political, economic and social inequities in virtually all societies in the world are suffered by women. Gender issues are issues of discrimination and marginalization that prevent women from benefiting equitably from the resources available in the family, the community, the state and society in spite of women being the main custodians of biodiversity at household and local levels.[9]

The more visible inequities are those that result from class-based differentials in power, opportunities and resources. The less visible and oftentimes overlooked inequities are gender-based inequities. While class-based inequities should not be tolerated and must be urgently addressed, there is as much urgency in addressing gender-based inequities because these have been responsible for the untimely death[10], ill health and poverty of millions of women.

Women and girls constitute the greatest majority of the world's poor.[11] In the same social class, there is a higher rate of unemployment among women compared with men.[12] The ratio of malnourished women to men is overwhelmingly high. Men dominate public decision making with women mostly relegated to the domestic sphere.[13] This is the special situation of poor women that requires particular attention in every policy and programme.

There is need for policy and mechanisms that explicitly address gender-based inequities because of the tendency to conflate gender with social class inequities. For instance, in policy or programmes that focus on poverty reduction, there is a tendency to expect that the benefits will be enjoyed equitably by both men and women. The reality, however, is that within poor communities there are structures that rationalize the subordination and oppression of women. A good example of these structures are socio-cultural norms that model a good woman to be subservient and domesticated; of the ideal mother who subsumes her needs to those of her family.[14] What is the implication of these norms and of the special situation of women to their share in benefits or access to products derived from biodiversity or human genetic resources? There are several serious implications.

First, the fact that among the poor, they are poorer, means that products developed from biodiversity or human genetic resources such as medicines could be inaccessible due to their poverty. While it can be reasonably argued that poor men too would not be able to afford these medicines, poor women's access is obstructed by two intersecting factors: poverty and gender based bias whereas that of men's access is obstructed only by poverty.

How does gender and poverty intersect such that access is more difficult for women? In poor households, women as a result of their socialization to the gendered norms of their society, under-prioritize their health needs when there are demands for the scarce economic resources of the household by other members of the family. They would sacrifice their own health condition in order that the needs of their children or husband could be met.[15] The situation would be different for women in well-resourced households. Poor women, therefore, suffer the consequence of the impact of the combination of poverty and gender inequity.

Second, in decision making on the distribution of benefits, women could be excluded from participation. The fact that universally men dominate the public discussion and decision making is illustrated in many actual cases of negotiations and decision-making for benefit sharing of biodiversity, involving local indigenous communities or governmental agencies where women, if at all they are participants, constituted only a small minority in the councils that represented their communities.[16] There are socio-cultural, political and economic barriers in every society that preclude poor women's meaningful participation in matters of public concern.

The participation of women, even if they only constitute the minority could be meaningful if they are able to influence the process and outcome of decision making. It is not only their physical presence that is required – for this could simply be token participation. The quality of their participation is also essential.[17]

In other words, addressing the inequities suffered by poor communities does not necessarily result to addressing specific disadvantages suffered by women or their particular needs. An international ABS regime that attends to inequities between rich and poor countries or a national regime that attempts to protect vulnerable communities, without explicit proviso for women's participation and entitlements could be unfair to women.

Gender Issues in Indigenous Societies

The rapid expansion of the commercial global biotechnology industry poses particular threats to indigenous people. This is a driver of increased research on biodiversity resources, especially genetic resources for commercial products (e.g. cosmetics, health foods). The growth of this industry meant greater intrusion in indigenous peoples' areas in developing countries where much of the biodiversity genetic resources are found and used by local people. As is often the case, access to and benefit sharing in resources from biodiversity are issues confronting indigenous peoples who are faced with dilemma of lack of awareness and tools to be involved in decision making.

Is gender a relevant issue in indigenous societies? The egalitarianism characteristic of indigenous societies is fast becoming extinct due to changes brought about by their interaction (in many cases, imposed) with the dominant society.[18] Hierarchical and consumerist values are making inroads in indigenous societies indicated in increasing reports of domestic violence, the transformation of women from equal partners in economic activities to dependents confined to household work and sexual abuse.[19]

Indigenous women suffer greater discrimination than other women. The combined effects of ethnicity, gender and poverty[20] make them among the most marginalized and impoverished women. These are layers of discrimination that impact indigenous women's access to and control of resources.

However, indigenous societies are usually perceived as homogeneous, meaning that while they are considered to be highly vulnerable to exploitation and deserving of protection, there is no differentiation in the vulnerability and marginalization of men and women. This is a gender-blind perception. In reality, there are significant differences in the nature and degree of vulnerability and marginalization of men and women in these societies. These important differences can be identified and understood with the use of the gender lens.

Only very recently has there been a major international instrument, the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) that explicit provision is made against the discrimination of indigenous women. However, like many other UN declarations, this instrument is not legally binding although because of its moral weight it can be used to advocate for indigenous women's rights in an ABS regime.

Using the Gender Lens in Constructing ABS Governance

In Yokohama is a holograph building designed by Hiro Yamagata. A prominent feature of this building is the solar cube. The building's colour, shape and visual impact change when the viewer moves from one spot to another. This is an apt metaphor to illustrate the importance of perspective in our understanding of things.

With out the use of a gender lens, vulnerabilities and inequities would be seen as similarly experienced; a gender lens will surface the differences between men and women. If the perspective is focused on poverty alone without its link to gender, then women's interests in access to and share in benefit from biodiversity and other genetic resources could be overlooked. If a gender lens is used, then women's concerns will be an integral part of the policy, mechanisms and structures of the access and benefit sharing governance whether from biodiversity or from human genetic resources, at the international and national levels.

Ways for Mainstreaming Gender in ABS Governance

There has been substantial progress in the past three decades towards international recognition and protection of women's rights in many social and human development programs. In health and human rights, good examples are the UN Conference on Population and Development

(Cairo 1994) declaration, the Convention on the Elimination of Discrimination against Women (1975), the World Conference on Women (Beijing, 1995) and the Millenium Development Goals (MDGs). In biodiversity conservation and protection, the Convention on Biological Diversity (Rio de Janeiro, 2002) stands out for its preamble that recognizes the need for the "full participation of women at all levels of policy making and implementation for biological diversity and conservation"[21] There have been important initiatives for mainstreaming gender in the implementation of the CBD such as those done by UNEP, IDRC, GTZ, FAO and UNDP.

However, there is a gap between good intentions as expressed in these various global policies on one hand and implementation on the other. Despite advances in legal rights, the actual state of women's rights is dismal.[22] Therefore, efforts to realize these policy pronouncements at local, national, regional and global arenas should continue. The time is opportune to advocate for gender mainstreaming in ABS governance because the meetings and negotiations are taking place at the committee level.

The Office of the Senior Gender Specialist of the World Conservation Union (IUCN) has produced an excellent policy brief for mainstreaming gender in ABS as part of its advocacy for gender equity in the environmental sector.[23] The brief makes a strong case why women should be involved in the ABS governance. It also puts forward doable ways for mainstreaming gender. Among the basic principles underlying the recommendations are: (a) gender-sensitivity in designing, planning, consulting on the content and structure of the ABS regime; (b) provision of empowering environment for women to access and share in the benefits; (c) development of women's capability to participate meaningfully; and (d) redressing gender inequity in the distribution and use of benefits.

ABS Regime that Upholds Gender Equity

The unity of process, content and outcome is what is needed now. The outcome of any project is usually affected by the kind of process that it utilizes. If the project (like the construction of an ABS regime) is inclusive and consultative, ensuring the meaningful participation (as explained earlier in this paper) of the marginalized and oppressed, the outcome of such a process will reflect the interest of these groups. On the other hand, if the consultation and negotiation are sensitive only to the voice of the dominant or articulate, much of the concerns of those who have no voice will be excluded in the final outcome.

However, the method for encouraging women to participate should consider their subjective and objective situation. This means recognizing that women could subjectively believe they have no right or capability to participate. They could therefore refuse to participate even if they are entitled to participate. Or it could be that their objective experience has given them valid reason to fear the consequence of participating, as for example it would take time away from their multiple domestic responsibilities and cause domestic trouble.[24]

The process for involving women should consider this reality as well as women's time constraints. It should be innovative to enable women who have no experience at all in this type of activity to speak. It might take time for some of them to voice their needs and aspirations.[25]

Conclusion

It was shown that socio-cultural, political and economic disadvantages are suffered by women because of their gender. However these disadvantages are oftentimes overlooked even in well intentioned policies and programs that sought to address poverty and inequity. An ABS regime that ignores this reality will contribute to the perpetuation of gender inequity.

Gender issues are complex and deeply rooted in society. Women's disadvantaged position, their own subjectivity about their persona and roles as well as the barriers that keep them from meaningfully participating in negotiations and decision making about access and benefit sharing requires a nuanced, sensitive and holistic approach. Top-down, narrow, technical and male-dominated mechanisms will not encourage women to meaningfully participate and enable them to equitably share in the benefits.

Legislating poor women's meaningful participation is easier than implementing it. ABS governance both at the national and global levels should include mechanisms for building women's capability and helping them empower themselves through equitable access and benefit sharing.

Endnotes

[1] Nijar (2008).

[2] Hamilton (2006).

[3] Convention on Biological Diversity. At http://www.mabs.jp/cbd_kanren/jouyaku/jouyaku_01_e.html (Accessed March 12, 2007)

[4] Castillo, Feinholz (2006).

[5] Tobin, Lorena (2007).

[6] Castillo (2001).

[7] Wong (2000).

[8] Tobin, Aguilar (2007).

[9] Castillo, Feinholz (2006).

[10] Nobel laureate Amartya Sen calls this the phenomenon of the "missing women", meaning that more than 100 million women have died prematurely due to unequal access to resources. See Sen A. December 1990. More Than a Million Women are Missing. The New York Review of Books. 37(20): Page Feature.

[11] Division for the Advancement of Women (DAW), Department of Economic and Social Affairs. 2000. Gender Equality, Development and Peace for the Twenty First Century: the Feminization of Poverty. New York:DAW/UN.

[12] Moss (2002).

[13] PAHO (2003).

[14] The patriarchal ideology of the family depicts women as dependents of men, their needs provided for by the men; women's identities are in relation to their social and biological reproductive roles. See Howard J and J Hollander (1997).

[15] Santow (1995).

[16] Illustrative examples are the San and Kani peoples' negotiations for benefit sharing and allocation of funds relative to their biodiversity resources with business corporations and governmental bodies. The reports on these cases are available at http://www.uclan.ac.uk/genbenefit

[17] In the Philippines, the increase in the percentage of women in the national parliament over the years is mainly a function of political dynastism where wives, sisters or daughters stand for elective positions when the male politicians in the family are prohibited by law to be elected to the same public office for more than three consecutive terms. The female relatives are there to keep the position for the family until the time that the male politician can stand be elected to the office again.

[18] Kathrin Wessendorf (2004).

[19] A good source on the current situation of indigenous and non-indigenous women in India is the 2-volume work of R Indira and Deepak Kumar Behera. Eds. 1999.

[20] Most indigenous peoples are the poorest in the world. See Wassendorf. Op cit.

[21] Convention on Biological Diversity. UNEP/CBD: Preamble. Available at: www.biodiv.org/doc/legal/cbd-en.pdf. Accessed July 29, 2006

[22] Molyneuz, Maxine (2002).

[23] Alvarez Castillo F. (2001).

[24] This risk of harm is not only a subjective fear of women. It could in fact be objectively a real threat. For example, in a project intended to capacitate women to become community leaders, some of the officials of the women's organization that was formed during the project were battered by their husbands for neglecting their domestic duties by attending meetings and trainings. See Estandarte, N, Segovia, L and Alvárez-Castillo, F. 1999.

[25] An example illustrates this: during a study into women's health needs, when they were asked about their health needs during interviews, the women talked only about the needs of their children, their husbands and their parents. It was only after probing that they began to talk about their own needs - for livelihood, reproductive health services, safe and accessible water, firewood, etc.

[25] In Galvez Tan J, F Alvarez Castillo et al. 2006.

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Monitoring Compliance under an International ABS Regime: The Role of an International Certificate Scheme

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Abstract: One area of compliance which has received significant attention over the years relates to a potential compliance monitoring tool viz. international certificate issued by domestic authorities. This paper provides a brief overview of existing proposals for an international certificate system and of the report of the Group of Technical Experts (GTE) established by the CBD to consider on the practicality, feasibility and costs of certificate proposals. In developing any certificate system the aim of negotiators should be to develop a bureaucratically light, inexpensive, flexible system. Work should focus first on identification of the elements and procedures for any regime, only then should attention be given to what any system will be called. In this way the system will define its own name and not vice versa. Certificates should be designed to provide the information necessary for monitoring at checkpoints

Keywords: ABS, Material Transfer Agreements, TK, CBD.

Introduction

Negotiation of an international ABS regime, which has stumbled along since 2004[1], got a much needed shot in the arm at the 6th meeting of the working group on ABS (WG ABS). Adoption of a novel working methodology enabled negotiators to agree on components requiring further elaboration with a view to their incorporation in an international regime. These components are set out in five blocks that comprise fair and equitable benefit sharing, access to genetic resources, compliance, traditional knowledge associated with genetic resources, and capacity.

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The inclusion by the WGABS of compliance as one of the principal components for elaboration of an international regime may prove a decisive step in the negotiation process. Compliance, an issue which has been surprisingly marginalized in debates on ABS over the years, is at the heart of developing country calls for negotiation of an international regime. This is, however, only a very preliminary step and compliance issues are likely to prove amongst the most controversial and challenging areas facing negotiators of an international ABS regime.

The 6th WG ABS identified three areas of compliance in which there is consensus regarding the need for further elaboration of measures[2]. These include:

1) Development of tools to encourage compliance:
   (a) Awareness-raising activities
2) Development of tools to monitor compliance:
   (a) Mechanisms for information exchange
   (b) Internationally recognized certificate issued by a domestic competent authority
3) Development of tools to enforce compliance

One area of compliance which has received significant attention over the years relates to what the 6th Working group has described as an international certificate issued by domestic authorities, a potential compliance monitoring tool. This paper provides a brief overview of existing proposals for an international certificate system and of the report of the Group of Technical Experts (GTE) established by the CBD to consider on the practicality, feasibility and costs of certificate proposals. It then suggests a model and highlights some of the challenges that will be faced in developing a functional international certificate system.

Certificates of Origin, Source, Legal Provenance or Compliance

Monitoring access to and use of genetic resources and traditional knowledge is considered crucial for effective ABS and TK governance. At present the collection, storage, use and transfer of such resources and knowledge is subject to an ad hoc system which often involves multiple forms of documentation. This includes government permits for the collection, export and import of resources, international obligations for sanitary and phyto-sanitary reporting, internal requirements of *ex-situ* collections, and reporting necessary to meet users demands. This plethora of documentation may provide a means to track back and identify the country of origin or legitimate provider of resources. Too often, however, different standards in record keeping breaks the chain of custody, resulting in what may be considered a loss of identity of the resources. An inability to demonstrate the origin or source of resources affects the capacity of enforcement agencies to monitor resource use and to ensure it is legal and conforms to the terms and conditions for its use. This in turn diminishes possibilities for enforcing benefit sharing obligations under the CBD.

Proposals for some form of international standardized system to document genetic resources and/or TK emerged soon after the entry into force of the CBD. An initial proposal for a CITES style permitting system[3], was soon followed by a proposal for what was termed "certificates of origin".[4] The certificate idea in particular caught on and proposals now also exist for certificates of source, legal provenance and compliance.[5]

A certificate of origin[6] would identify the country of origin of resources and provide evidence of PIC for its use.[7] The CBD defines a country of origin as a country having resources *in-situ*, and for domesticated crops and animals, where they developed their distinguishing characteristics. Under the CBD provider countries includes countries of origin and countries which obtained the resources in accordance with the CBD (Pre-CBD collections would not be covered). The issuance of certificate of origin in cases where TK is involved would be subject to PIC of indigenous peoples or local communities.[8] Certificates would be monitored through a system of checkpoints, such as intellectual property (IP) applications and product approvals procedures.[9] A certificate of origin system would in effect transfer the burden of proof regarding rights to use resources from the provider to the user.[10]

Certificates of source were suggested as an alternative to those of origin due to concerns that identification of the geographical origin of resources could prove impossible.[11] Sources to be certified would include primary sources (such as the Contracting Party providing resources, and the Multilateral System established by the FAO-ITPGRFA), and secondary sources (such as *ex-situ* collections, databases on genetic resources and traditional knowledge, and scientific literature).[12] Certificates would be linked to obligations for disclosure of the source of genetic resources and TK in patent applications. Patent authorities would be obliged to inform competent authorities of countries identified as the source of genetic resources and/or TK of relevant IP applications where the source is declared.[13]

Certificates of legal provenance focus on the legality of use rather than on the issue of where resources are obtained.[14] They would provide evidence of the geographical origin of resources and of compliance with the access laws of the providing country.[15] Certificates would be recorded in an international clearing house, with users obliged to maintain the link between the certificate and genetic resources.[16] Certificates could be requested at specific check points related to grant of IP rights, product approvals, grant making, and journal publications. A recent paper suggests they may be worthy of consideration as a possible tool for distinguishing TK legally in the public domain from that which has fallen into the public domain as a result of breach of a contractual or fiduciary duty, or due to misappropriation.[17]

The most recent proposal is for what are termed certificates of compliance. The term, which has become immediately popular, is used in the proposal to apply to cases of compliance with domestic ABS regimes.[18] This proposal favours a system of internationally recognised certificates rather than a globally harmonised certificate. Its proponents have argued against the establishment of checkpoints to monitor certificates and resource use. The proposal would exclude TK from any certification system.[19]

The potential of a certificate system to form a part of an international ABS regime led COP 8 to establish the GTE which met in Lima in January 2007. The Group's report identifies a number of features common to all four proposals, including: (i) a certificate would be a public document issued by a competent national authority; (ii) it would serve to provide evidence of compliance with national ABS legislation; (iii) it could be required for presentation at specific checkpoints in user countries (iv) all models could cover all genetic resources.[20] Furthermore, the group considered that a mandatory system would be restricted to the scope of the CBD, while a voluntary system might extend beyond the Convention; potential benefits of a certificate system were likely to increase with greater participation of parties at both the user's and provider's end; and a paperless system is favourable, however, any system should be flexible enough to allow for a mixture of paper and electronic formats.[21] The Group took the position that due to its intangible nature TK poses practical difficulties requiring special consideration before development of a TK certification scheme.

The 6th WGABS took the decision to include an international certificate issued by domestic authorities within the areas for further elaboration with the aim of their inclusion in an international regime. To this end, it has been proposed that the WGABS be given a clear mandate to prepare a set of minimum standards and procedures for an international certificate system and to provide the results of its work for consideration by COP 10 in Japan in 2010.[22]

Potential Elements and Procedures for a Certificate System

This section provides a brief overview of issues which the WBAGS and GTE may wish to take into consideration in the development of minimum standard elements and procedures for an international certificate system. This is an indicative list of issues for consideration and is not intended to be exhaustive. The issues for consideration set out below have been prepared based upon analysis of: all four certification proposals and the report of the GTE; existing harmonsied documentation procedures such as those developed by the International Plant Exchange Network (IPEN)[23] and MOSAICC[24]; case studies on documentation practices of *ex-situ* collections, including the Royal Botanical Gardens Kew, the Smithsonian Institution and INBio[25]; innovative models for contractual procedures to govern resource management, such as those of the International Treaty on Plant Genetic Resources for Food and Agriculture[26], Science Commons[27], the Potato Park[28] and Yellowstone National Park; conclusions of a series of international expert meetings on certificates[29]; as well as review of the writings of numerous commentators[30]; statements by industry sectors; and reports prepared by international organisations.

The paper seeks to avoid the often unproductive debate over what any certification regime should be called, and focus attention instead on the objectives, nature, content and scope of a certification system. Leaving what it should be called to emerge from the nature of the system itself.

What is the Purpose of Certification?

In order to determine the purpose of certification it is first necessary to consider what certification is and what it is capable of. Generally a certification system serves as a system for confirming the accuracy of something, or guaranteeing the meeting of a standard.[31] The certificate itself may serve to provide evidence of a legal right such as in the case of a certificate of title to a car[32], or act as a mark designating the quality or nature of goods or services as, for example, the "AAA Approved" sign found at hotels.[33]

In the context of ABS and TK it has been suggested that a certificate system may certify such issues as the origin of genetic resources, the source which provided resources, their legal provenance, i.e. that they have been obtained in accordance with the CBD, and compliance with relevant ABS laws.

Scope

Certificates will need to be flexible to enable certification of anything from a single sample to multiple collections under a single ABS agreement. The CBD will need to define derivatives to ensure that as resources undergo transformation documentation will continue to be held linking transformed resources and the certificate which covers such resources. This should be held at least up to the stage when benefit sharing rights are exhausted.

Further work is required to determine whether certificate should cover associated TK, and/or whether a stand-alone system for certification of TK is appropriate.

Nature

Certificates if they are to play any serious role as a tool to monitor compliance, should demonstrate compliance with relevant ABS legislation of provider countries as defined under the CBD. To this end they will need to certify the origin, source, and/or legal provenance of resources. Certificates will need to provide evidence of PIC and MAT in order to provide legal certainty which will be the principal incentive for their use by industry and the research sector. Certificates will prove more useful if they raise a presumption of fair and equitable benefit sharing. This presumption will need to be rebuttable in cases of fraud, misrepresentation and other unfair trading practices.

A system of certificates may be either mandatory or voluntary. If mandatory it is possible that it may be restricted to resources covered by the CBD. A voluntary regime could also potentially be extended to pre-CBD collections and resources collected outside national jurisdiction, such as Antarctica, the high seas, and deep sea-bed (these will be discussed further below). An incentive based system would seek to promote use based upon the benefits for users of legal certainty arising from certification.

With regard to TK certification should be based upon PIC of indigenous peoples and local communities, and should be made with due regard for customary law and practice.

Format

The certificate of origin proposal suggests a form of passport that accompanies genetic resources, either through their entire history from collection to use ('cradle to grave'), or only for certain transactions.[34] The GTE supports a paperless system, but recognizes the need for any system to incorporate paper based certificates as well due to differences in technological capacity of countries.

There is growing use by a wide range of actors of systems of unique identifiers, including barcodes, and digital object identifiers (DOIs) as a means to identify resources and aid in their future tracking. Where DOIs are in use, these are usually managed by an international online registry. Use of identifiers would enhance the possibilities for maintaining a link between resources and the certificate and terms and conditions applying to them. Such a linkage would reduce cost, complexity and enable instant verification and reduce the opportunities for the fraudulent use of false certificates.[35]

Certificates may be designated as non-transferable; transferable upon agreement to be bound by the same terms and conditions as applied to the original access; or, transferable only upon due notification to the provider country or indigenous peoples or local community, and their acceptance of such transfer. Provider countries and indigenous peoples and local communities may develop online systems to administer such transfers.

Issuing Authority

Certificates would be issued by a competent national authority in a provider country, as defined by the CBD. Certificates of legal provenance might also be issued by international genebanks of the CGIAR system for transfers covered by the ITPGRFA; this would avoid the placing of bureaucratic constraints on transfers covered by the Treaty. Potential authorities for issuing certificates for pre-CBD collections and collections from outside national jurisdiction are discussed below. In order to avoid delays and further bureaucracy certificates should be automatically issued upon completion of an agreement based upon mutually agreed terms (MAT) in compliance with national ABS laws. An exception would be in cases where the contract's validity itself is challenged in accordance with national law. Certificates should be issued with little if any charge.

In the event that TK is to be covered by certificates, these may be issued by a national authority to demonstrate compliance with national legislation regarding PIC and MAT of indigenous peoples and local communities, for use of their knowledge and resources. Procedures for certification of TK should be managed where possible by a competent national authority representing and/or administered by representatives of indigenous peoples and local communities.

Indigenous peoples and local communities may also seek to develop their own certification authorities to demonstrate compliance with their customary laws and practices. Community protocols establishing clear procedures for certification of compliance could help to empower community control over PIC and MAT procedures.

Distinction between Commercial and Non-Commercial Use

Any certification system should avoid creating unnecessary costs and deals for pure scientific research, which covers a majority of access applications. Certification procedures may usefully adopt a two-tier system for commercial and non-commercial research. Researchers would be obliged to return to the provider country or indigenous people or local community for further PIC and MAT in the event of a desire to move to commercial related research and development activities. The terms and conditions for access may, in some cases, allow for such a change in use subject only to notification, where subsequent commercial use is governed by standard terms and conditions established by the rights holders.

Standard Material Transfer Agreements

Adoption of online access contracting systems employing standard material transfer agreements (MTAs) could greatly facilitate access to resources and TK. Increased access will increase the possibilities for discoveries of scientific and/or commercial importance and benefit-sharing opportunities for rights holders. Online systems may allow for click-licensing. Shrink-warp licensing systems may also be envisaged where receipt of resources and opening of their packaging amounts to acceptance of contractual provisions. The use of standard MTAs would benefit providers in what may often be asymmetrical negotiations with users. Online systems may be established with a minimum of infrastructure which would benefit developing countries, and indigenous peoples and local communities wishing to manage their resources and provide them for access to a wider market. A set of standard agreements for non-commercial and commercial research could be developed by the CBD as has been done under the ITPGRFA.

Provider countries and other rights holders may decide to limit online licensing to resources which are widely available, or which are considered to have little commercial value. Obtaining access to endemic resources and high value resources such as extremophiles may require face-to face negotiations. Likewise, indigenous peoples and local communities may designate TK which may be accessed over the Internet and restricted knowledge which can only be accessed following face-to-face negotiations, if at all. Any decision to provide for online licensing of resources or TK would be the sole prerogative of relevant provider countries and indigenous peoples and local communities themselves.

The viability of online systems will depend to a large extent upon the existence of a robust system of user measures to ensure that contracts are complied with and where there is a breach there are effective and accessible remedies. Contract law alone will be insufficient to ensure protection of rights against third parties not party to a contract for use of resources. User measures such as disclosure requirements in IP applications will also be required to can help prevent misappropriation of resources and TK.

Clearing House Mechanism

A clearing house mechanism may be established to provide for register and tracking of all certificates.[36] This would bring transparency to the system and enable both providers and users to identify valuable resources. This may assist provider countries to regulate more effectively their resources, both for commercial purposes as well as to direct more effectively their scarce funds for conservation purposes.[37] Where there is online management of resources these systems may be networked providing greater access to information on resource use complementing a CHM, or in essence establishing a virtual CHM, through remote nodes.

Checkpoints

A majority of certificate proposals envisage their use in conjunction with one or more commercial and/or non-commercial checkpoints such as intellectual property and product approval application procedures, other statutory approvals procedures, as well as in grant making and publications.

Checkpoints should be linked to high end use of resources and should not burden non-commercial users with unnecessary and costly procedures.[38] Placing checkpoints late in the stage of research and development will reduce costs for provider countries of any system and place the costs more firmly upon the users. If checkpoints are to prove effective in creating incentives for users to seek out PIC and MAT they will need to have substantive effect on procedures for granting of intellectual property, product approval, etc.

The principal checkpoint proposed by certificate schemes is for disclosure requirements in IP applications procedures. Proposed disclosure requirements range from a transparency measure in the form of disclosure of source[39], to more substantive measures including disclosure of origin and of evidence of PIC.[40] Disclosure requirements in national law have now been adopted by both developed and developing countries, including Brazil, Costa Rica, Denmark, Egypt, Germany, Norway, New Zealand, Romania, Spain, Sweden, Switzerland, and India. At the regional level, the European Community has opted for voluntary disclosure while the Andean community has adopted mandatory obligations. At the international level proposals have been made for amendment of World Trade Organisation (WTO) TRIPS Agreement to include disclosure requirements, covering origin, PIC and fair and equitable benefit sharing. A majority of WTO member countries now support such proposals.[41] Switzerland has proposed amendment of the Patent Cooperation Treaty to establish mandatory disclosure of source requirements.[42]

Care will need to be taken to ensure any disclosure requirements are drafted in terms which reflect the rapidly advancing pace of technological change. Advances such as those such as genomics and bioinformation now enable significant use to be made of genetic information without the need for physical access to genetic resources themselves.[43] Disclosure requirements will need to be couched in terms which address such indirect use of resources.[44]

Users providing a valid certificate should be presumed to have a legal right to use resources for the purposes identified on the certificate or related terms and conditions of contract. They should also be presumed to have complied with national requirements on PIC, MAT and fair and equitable benefit sharing. This presumption as stated above should be rebuttable under certain circumstances.

Traditional Knowledge

Indigenous peoples and local communities are as yet undecided on the appropriateness of applying certification to TK. If certification is to occur consideration will need to be given to the potential and limitations of different types of certificate systems. Certifying origin would require identification of the originators of TK or its cultural origin; certificates of legal provenance for TK may provide means to distinguish information which has fallen into the public domain due to breach of contract or of a fiduciary obligation or as the result of misappropriation; certificates of source might apply to TK held in public or private databases which cannot demonstrate a clear legal title for their commercial use (in which case, access should be limited to non-commercial use). All certificates would, in essence, be a form of certificate of compliance demonstrating conformance with national ABS and TK laws and/or customary law and practice of indigenous peoples and local communities.

Considering the complex nature of TK systems, a special meeting of TK experts should be convened in order to weigh up the merits and drawbacks associated with applying any certification system to TK.[45]

Pre-CBD Collections

Where genetic resources and knowledge are in circulation outside the scope of an international ABS regime and certification system this may undermine their effectiveness, creating legal uncertainty and loopholes for unscrupulous users. The CBD does not explicitly extend its provisions to pre-CBD collections, though some countries have argued that all post CBD transfers of resources should be carried out in compliance with the CBD's provisions on PIC and MAT.[46]

The proposal for certificates or origin would, in effect, exclude pre-CBD collections held in countries other than the country of origin. The certificate of source proposal might allow for certification of resources from pre-CBD collections held in provider countries. It has been argued that as pre-CBD collections are not explicitly addressed by the CBD, they are legally held and could, therefore, be granted certificates of legal provenance.[47] The certification of compliance proposal would exclude all pre-CBD resources from coverage. The GTE has suggested that resources which fall outside the CBD may be incorporated in a voluntary system of certification. Whatever form a certification system might take there are likely to be incentives and pressure for *ex-situ* collections with pre-CBD genetic resources to bring them within a system of certification.[48] One potential solution would be for institutions holding pre-CBD collections to adopt the approach of IPEN's Common Policy Guidelines[49] that require member institutions to treat both pre-CBD and post CBD collections in the same manner.

Commercial bioprospecting activities in Antarctica, the High Seas and the deep seabed remain largely unregulated. Discussions are now ongoing in various international forums regarding the development of measures to regulate bioprospecting activities in areas beyond national jurisdiction. It has been proposed, for instance, that the Antarctic Treaty System (ATS) might be extended to include regulation of bioprospecting.[50] If this is done the ATS could also assume responsibility for certifying the legal provenance of resources. Bioprospecting activities on the High Seas are at present subject to flag State jurisdiction.[51] Therefore, the flag state may be entitled to certify the legal provenance of resources. This has the dangers of having the flag country act as both judge and jury of legitimacy of collections. With regard to deep seabed resources the mandate of the international seabed authority could be amended to cover bioprospecting activities. Alternatively amendment of the CBD might be sought to encompass bioprospecting of resources collected on the high seas and the deep seabed.[52]

The lack of a clear regulatory framework and procedures for regulating commercial bioprospecting on the deep sea-bed has been seen as a deterrent to investment in such research on the deep seabed[53] and in Antarctica.[54] Bringing such resources within the ambit of an international ABS regime and certification system could help to bring greater legal certainty and boost investment. One potential means for doing so would be through disclosure requirements in IP legislation. A blanket requirement obliging IP applicants to disclose the origin or source of resources and provide evidence of a legal right for their use could be applied equally to resources covered by the CBD and resources which do not fall within its remit. This is not a decision which could be taken by the CBD alone. However, an amendment to TRIPS requiring disclosure of origin, PIC and fair and equitable benefit sharing could be framed so as to apply to all genetic resources wherever obtained.

Further analysis of the relationship of a certificate system with genetic resources which are not covered by the CBD is required, including investigation of: (i) modalities of an international certificate system which could create incentives for voluntary inclusion of non-CBD resources; (ii) measures for mandatory application of a certification system to pre-CBD collections and/or genetic resources collected beyond national jurisdiction; (iii) options for exemption of resources from any system; (iv) measures to mitigate the impacts of trade in genetic resources outside any international ABS regime and certification system.[55]

Capacity Building and Further Research

There is, a need for further information on current practices in the documentation and management of resources and TK, in particular regarding the practices of industry and the research sectors as well as indigenous peoples and local communities. There is also a need for targeted case studies and pilot projects on implementation of certificates at the national level and across whole chains of use from cradle to grave. Funding for GEF medium sized projects on ABS capacity building could provide a means for carrying out of pilot studies.

Conclusions

Certificates have a potentially important rôle to play as a compliance tool in an international ABS regime. They are, however, only one of a range of tools which will be required to establish a functional regime. They cannot be expected to resolve all the problems associated with current ABS and TK governance. Certificates in themselves are not an enforcement tool but when linked to a system of checkpoints they may play a significant role in protection of rights over genetic resources and TK.

The WGABS and GTE should begin work to prepare a set of standard elements and procedures for an international certificate system to be considered by COP 10, in Japan in 2010. To inform its work the WGABS should promote the carrying out of case studies and pilot projects. COP should call upon GEF as well as governments, international organizations and aid agencies to make funding available in the short term for necessary research and capacity building in this area.

In developing any certificate system the aim of negotiators should be to develop a bureaucratically light, inexpensive, flexible system. Work should focus first on identification of the elements and procedures for any regime, only then should attention be given to what any system will be called. In this way the system will define its own name and not vice versa.

Certificates should be designed to provide the information necessary for monitoring at checkpoints. To this end consultation should be carried out with authorities who may be called upon to enforce any system such as customs, patent authorities, police, judiciary etc.

Analysis of certification proposals and a wide range of related projects and experiences demonstrate that certificates can be practical, feasible and cost effective. Efforts should be made to secure the full and effective participation of all rights holders and stakeholder groups in the design of a certification system.

Endnotes

[1] The WG ABS was given a mandate to negotiate an international regime on ABS and related traditional knowledge (TK) by the 7th meeting of the Conference of the Parties (COP) to CBD, held in Kuala Lumpur in 2004.

[2] UNEP/CBD/COP/9/6

[3] Downes (1993).

[4] Tobin (1994).

[5] For general analysis of certificate proposals see Tobin, Burton and Fernández 2008, Ute and Wolff 2007, Barber, Johnston and Tobin 2003. For discussion of certificates of origin Tobin 1997 and 2000; on certificates of sources, Girsberger 2004 and 2004b; on certificates of legal provenance, Fernandez 2004, 2005 and 2007; and, on certificates of compliance, Australian submission to CBD 2007.

[6] Certificates of origin were first proposed as part of a wider proposal for a system of disclosure of origin in patent application procedures. Tobin B. (1994).

[7] Tobin, et al (2008).

[8] Tobin (2000).

[9] Tobin (1997). Mugabe, et al. (eds.) Access to Genetic Resources: Strategies for Sharing Benefits. Nairobi: ACTS Press.

[10] Tobin et. al. (2008).

[11] Switzerland. (2003), available at http://www.wipo.int/edocs/mdocs/pct/en/pct_r_wg_5/pct_r_wg_5_11_rev.pdf

[12] Girsberger (2004).

[13] ibid.

[14] Fernández J.C. (2004), available at http://www.canmexworkshop.com/papers.cfm

[15] Fernández (2005).

[16] Fernández (2007).

[17] Tobin, Burton, and Fernández (2008).

[18] Australia (2007).

[19] ibid.

[20] Report Of The Meeting Of The Group Of Technical Experts On An Internationally Recognized Certificate Of Origin/Source/Legal Provenance UNEP/CBD/WG-ABS/5/7.

[21] *ibid.*

[22] Tobin et. al. (2008).

[23] Gröger (2007).

[24] Desmeth (2007).

[25] Tobin, B., D. Cunningham, and K. Watanabe (2004).

[26] SGRP (2007), Available athttp://www.sgrp.cgiar.org/Publications/SMTA_PolicyBrief_WEB.pdf

[27] See Buck, M. (2005).
[28] See: http://www.parquedelapapa.org/
[29] See Dedeurwaerdere et al. (2004), Ute and Woolf (2007).
[30] See generally attached bibliography.
[31] http://www.thefreedictionary.com/certify
[32] Certificate of title n. generally, the title document for a motor vehicle issued by the state in which it is registered, describing the vehicle by type and engine number, as well the name and address of the registered owner and the lien holder (financial institution that loaned money to buy the car). http://legal-dictionary.thefreedictionary.com/certificate+of+title
[33] See definitions at http://www.discusslaws.com/terms/161/certification_mark.html
[34] Tobin et. al (2004).
[35] Desmeth (2007).
[36] Fernández (2007).
[37] Tobin et. al (2008).
[38] Fernández (2004).
[39] Switzerland (2003).
[40] Tobin (1997).
[41] Trips Council Once Again Marked by Divisions over Disclosure Amendment, Bridges Weekly, Vol12, No.10, 19 March, 2008, available at http://www.ictsd.org/weekly/08-03-19/story4.htm, last visited, 25 March, 2008.
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[43] Parry (2004).
[44] Tobin et al. (2008).
[45] Tobin et al. (2008).
[46] Fernández (2007).
[47] Dross M. and F. Woolf (2005).
[48] Tobin et. al. (2008).
[49] IPEN (2000).
[50] Lohan, D. and S. Johnston (2005).
[51] Salvatore, a. and C. Salpin (2005).
[52] *ibid.*
[53] *ibid.*
[54] Lohan, D., and S. Johnston. (2005).
[55] Tobin et. al. (2008).

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The Challenge of a New Regime: The Quest for Certainty in "Access to Genetic Resource and Benefit-Sharing"

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Abstract: The negotiations for an international regime on Access and Benefit Sharing (ABS) are beginning to pick up significant momentum after many years of work under the Convention on Biological Diversity (CBD). ABS regime is tangled with a myriad of issues still un-agreed regarding the nature of the ABS regime, the primary mechanisms for its operation, and especially, how the regime will be practically implemented and enforced. This article focuses on some of the key legal and related issues on ABS from the past experience and suggest some ideas for taking the negotiations forward.

Keywords: CBD, ABS, Genetic Resources, Scope, Definitions, Derivatives, Legal Status, Enforcement

This May, in addition to its extensive agenda, the Ninth Conference of Parties (COP) to the Convention on Biological Diversity (CBD) will hear the "next installment" of a long story – the saga of ABS. Spanning more than 18 years, the saga reflects the most difficult quest of the CBD – the effort to realize its third objective" of *the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.* (the "benefit-sharing objective or "ABS.") Work aimed at realizing a functional ABS system has been actively ongoing since 2004, pursuant to still unclarified mandates that were originally enunciated in 2002 at the Johannesburg Summit,[1] and later adopted by the CBD COP-7, which created the Ad Hoc Working Group on Access and Benefit Sharing (the

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"AHWG-ABS") to:

> *... elaborate and negotiate an international regime on access to genetic resources and benefit-sharing with the aim of adopting an instrument/instruments to effectively implement the provisions in Article 15 and Article 8(j) of the Convention on Biological Diversity and the three objectives of the Convention.*[2]

This article is designed to briefly summarises some of the complex issues of greatest important to the negotiations, and explains their current status and the attitude of the negotiations at present.[3] It begins with a brief introduction to the issue, explaining why the issue exists at all and why solutions to its primary operating needs have proven so elusive up to now.

The simplest proof that ABS is complex is to notice that after 16 years, it still remains unclear to many who are otherwise supremely competent professional analysts of CBD matters. The brevity and simplicity of Article 15 was possible only because the CBD negotiators chose not to identify and agree on the details necessary for final agreement on what ABS is, how it functions and what its purposes are. All that is known is that ABS is the main tool for achieving the "third objective" of the CBD,[4] and that Article 15 gives some hints about the basic framework that the parties envision for achieving that objective. The primary components of Article 15 call upon the parties to do the following

> *[to] endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties.*
>
> *[to] endeavour to develop and carry out scientific research based on genetic resources provided by other Contracting Parties with the full participation of, and where possible in, such Contracting Parties; [and]*
>
> *[to] take legislative, administrative or policy measures ... with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the Contracting Party providing such resources.*[5]

To the non-lawyer or other person without legislative experience, these few sentences[6] may suggest that ABS is simple: one person or entity (the "user") obtains "genetic resources" from another person, entity or country (the provider) and in exchange offers "benefits."[7]

Alas, as further discussed in a great many writings on the topic, this simplified view is not actually what the CBD says, and is far from simple, from a practical and legal perspective.

In addition to Article 15, there are many other "ABS operative provisions" in the CBD (including technology transfer, biosafety, sharing of opportunities and repatriation of information[8]), all of which depend on the Article 15 framework.[9]

Progress to Date towards Realizing ABS

After the CBD was adopted, the parties almost immediately recognized that significant work would be required, just to figure out what ABS is and how to implement it. . In the ensuing years, work has progressed in four phases:

- ***First phase – promotion of national implementation.***

During the first 8 years following adoption of the CBD, the emphasis of national and international efforts was based on the belief that ABS could easily be implemented, if developing countries would only adopt provider-side legislation. During this period, the number of developing countries that attempted to adopt ABS legislation was variously estimated at between 50 and 100 countries. In the end, only approximately 35 have adopted any instrument mentioning ABS, and only about 18-20 countries (10% of CBD Parties) have adopted any regulatory measures or practices.[10]

- ***Second phase – development of the Bonn Guidelines:***

Beginning with COP V, it was clear that the cause of ABS failure was more than just a lack of developing-country legislative action. Both countries and users began to recognize the ABS concept, and the lack of a functional ABS system was becoming an impediment to commercial and research access to genetic and biological resources. International efforts focused on creating support and guidance for developing countries and institutions, still based on the idea that only provider-side measures would be needed. Guidelines and model instruments began to proliferate from many sources (primarily industry associations and NGOs), leading the COP to take on the task of developing of a definitive set of Guidelines – the "Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization"[11] Following their promulgation in 2002, the Bonn

Guidelines met with differing responses from different groups. Ultimately, there has been no noticeable increase in the number of countries that have adopted legislation, nor in the effectiveness or enforceability of existing national ABS systems since the adoption of the Bonn Guidelines.

- ***Concurrent phase – negotiation of the International Treaty on Plant Genetic Resources, and other work*[12]**

From the beginning, following the adoption of the CBD, FAO began to address the special application of ABS concepts to food and agriculture – especially the use of foreign germplasm in conventional crop variety development practices. In 2003, FAO adopted a new instrument, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA.) The ITPGRFA does not cover all genetic resources but only "plant genetic resources." It applies only when these resources are used "for food and agriculture." In addition, its primary mechanism, the "multilateral system for access to and use of plant genetic resources for food and agriculture," applies only to crops listed on Annex A to the Treaty, and only when the specific resources being accessed are held in national or international collections or are in the public domain.

- ***Current phase – international regime negotiations***

ABS implementation still lagged, however, due to uncertainties and legal problems. Eventually, in 2002's World Summit for Sustainability issued the first call for "the negotiation of an international regime on benefit-sharing", which ultimately led to the current ABS regime negotiations within the CBD. These negotiations have spent much of the first six years focused on determining what is meant by "negotiation of a regime," with some countries continuing to oppose negotiation of any instrument (presuming that more informal guidance and COP decisions will be sufficient) and others assuming that the "negotiation of a regime" means "negotiation of a CBD protocol."

The most recent meetings of the Working Group appear to have finally moved beyond those initial disagreements, with serious discussions focusing on the kinds of instruments (generally protocol, model instruments and compliance standards) that can be used to make the regime functional. If the Parties formally agree to move forward on such a framework, they will have taken the first step towards creating a functional system that could be implemented across national boundaries – *i.e.*, toward the realization of ABS. If adopted, however, these decisions will be only the first (relatively straightforward) step toward finalizing the regime. The next section will consider several of the complex open questions that must be addressed as the next step – determining what content will go into the proposed framework.

The Next Critical Issues to be Addressed

One general (and manifestly incorrect) assumption that is still sometimes put forward is the idea that ABS can be implemented with "only" two national actions: (1) all countries provide relatively universal "access" to their genetic resources, and (2) when someone (a user) utilizes genetic resources, the user country will ensure that a share in the benefits (financial and non-financial) arising from that use will go back to the provider of those resources. This creates an incomplete picture, for several reasons. The main reason is that at present there is no "agreed understanding" on the meaning of the basic elements of ABS. This lack has been recognized since the day the convention was adopted, and continues to be a major obstacle to ABS implementation,[13] primarily because, without such understanding each country would have to find a way to enforce 190 different national ABS laws within its own national legal system.

The process of creating a unified international regime has many layers. The following discussion focuses only on the next layer.

Incomplete Performance: User Measures and Provider Measures

The specific cause (*i.e.*, on-the-surface reason) of the failure of ABS to date, is the fact that CBD Parties have not adopted and implemented ABS legislation.[14] This deficiency has two sides. First, only about 18 developing[15] countries have adopted any ABS law. Those countries' laws focus only on the "provider side" – that is, they each address the process of granting permits and/or entering into contracts for collection and use of genetic resources from their own country.[16]

Second, *no country* has adopted any law implementing the CBD's required "user-side measures"[17] – that is, measures governing users under their jurisdiction who utilize genetic resources of foreign origin.[18] The international regime can only be functional if all Contracting Parties adopt *both* user-side and provider-side measures.[19] At present, the countries that are thought to have the largest number of users under their jurisdiction are unlikely to adopt any user-side measures until the legal issues are clear and consistent so that national ABS laws (both user- and provider-side) give legal certainty to users, providers courts and agencies.

Many people offer explanations for the failure to adopt ABS measures. Few of these have proven correct. Ultimately, the main reasons that seem to be supported by the facts are the following:

- Basic elements of the ABS concept remain unclear, making it impossible to adopt national ABS laws that are legally clear and implementable in countries which operate under the strict "rule of law."[20]
- The primary focus on "provider-side" measures means that nearly one half of every ABS transactions will be un-covered by any national law, enabling source countries to assert their rights.
- There is little or no incentive anywhere to encourage users or countries with significant number of users under their jurisdiction to take action toward implementing ABS. The ABS concept has not been a "give and take" between two sides. Countries/communities which see themselves as primarily providers expect benefits, but offering no obvious *quid pro quo* in the form of anything that appears desirable for users.

Taken together these points may explain the failure of ABS. Their relevance is clearest when one remembers that ABS is, by definition, an environmental social objective to be realized through the use of commercial law concepts of equity and benefit. Those concepts can only function when one has "legal certainty" about them, and when they are built on mutuality and agreement. The next section identifies many elements which have prevented countries from adopting commercially implementable ABS measures.

Incomplete Concepts

A legally certain ABS system must be based on certain primary agreements that will enable countries to adopt functional implementation measures. Even 16 years after the Convention was adopted, the ABS regime is still not clearly defined and agreed. While provider-side measures may take many different approaches, it is essential that they must meet certain agreed requirements, so that any user country can adopt a single cross-border mechanism to apply them.

Normally, a country cannot specify particular national legislative requirements to will apply to a particular kind of cross-border situations until all Parties have agreed on uniform elements. Specifically, in ABS, all countries' national law should be based, at a minimum, on agreement regarding (i) the coverage of ABS, (ii) the linkage between "access" and "benefit-sharing" and (iii) the manner in which the ABS relationship is completed or terminated.

Coverage: The primary concepts and their function in the system:

Normally, the "scope and coverage" of an instrument are built primarily through definitions. In ABS many concepts are misunderstood or subject to disagreement. The following discusses some of the most common definitional/scope concerns. [21]

a. "Genetic Resources": As of this writing, neither the COP nor any country has adopted a workable integrated system that explains the meaning of "genetic resource" in a way that would allow a government official or court to apply it. Specifically, it is not possible to look at any item and state whether it is a "genetic resource," which is covered by ABS, or a "biological resource," which is not.[22]

In the ABS negotiations, some parties assume that the meaning of "genetic resources" is or should be essentially identical to that of "biological resources."[23] Under that view, the legal owner of any plant, animal, microbe or any sample is also a separate owner of its "genetic resources" which are thought to be the genetic resources of the entire species. This could mean that any purchase or collection of any single biological specimen (and/or the use of any biological material in a product –as an ingredient in a bakery cake, for example) would constitute "access" to genetic resources.[24]

Another approach holds that the meaning of "genetic resources" is "the information contained in a DNA or biochemistry of a species, subspecies or variety." Under this approach, the biological material would be "an expression" of the genetic resources, in the same way that a published book or CD is "an expression" of the intellectual/artistic concept contained in the text or music. Like the owner of the individual book, the owner of a specimen of a species would not necessarily have the right to grant legal "access" to commercial or other use of the informational resources contained.

Currently many discussions simply adopt both views, without integrating them. This approach may be acceptable in countries whose legal systems are applied flexibly, however, it's inconsistency creates an almost impermeable barrier to implementation in countries who operate under strict concepts of the "rule of law."[25]

b. "Utilization of Genetic Resources": Another basic question which must be answered is *"When is the benefit-sharing system triggered, and what triggers it?"* Article 15.7 appears to require only two triggers for benefit-sharing: (i) a person or entity (user) "utilizes genetic resources" from another country, and (ii) some benefits "arise from that utilization."[26] Unlike the "genetic resources" definition (which cannot be pinned down concretely), it is possible to create concrete, externally verifiable definitions of "utilization of genetic resources." If the régime clearly defines "utilization of genetic resources," that definition can enable legal and administrative processes to know with certainty which persons are subject to benefit-sharing obligations – *i.e.,* persons engaging in certain activities or types of activities (*i.e.,* genetic manipulation and perhaps the creation of new plant varieties) – and what those obligations are. A regime based on "utilization" could regulate these activities without the need for to create an externally verifiable definition of "genetic resource."

c. "Benefits arising from the utilization of genetic resources": Similarly, a system for requiring, enforcing and/or motivating benefit-sharing could be functional at the practical level, only if the Parties can agree on the criteria for know when "benefits arise" from the use of genetic resources. For example, it will need to identify

- a clear point at which collected data become "research results" to be shared under Article 15.7 and/or repatriated under Article 17.2, and how sharing is to occur[27], and/or
- clear points at which the user's activities and results constitute a benefit (*i.e.,* is it only a "benefit" when money is paid for a product? If not, does filing a patent application constitute a benefit to be shared?? What about approving an item for production or marketing? Should "interim discoveries" which are not separately patented or marketed, be considered "benefits" to be shared?)

Linkage between Access and Benefit-Sharing:

Another question that is not yet clearly agreed is how "access" relates to "benefit sharing." Formerly, the simplistic view of ABS has held that benefit-sharing applies only to genetic resources obtained through licensed bioprospecting in the source country.

A few source/provider countries, as well as most users, appear to feel that ABS responsibilities only apply where the user specifically obtained a genetic resource from the source country directly – *i.e.*, by direct bioprospecting under an ABS permit.[28] Under this theory, if the material is acquired from a third-party (a collector, academic researcher or other third party), the transaction is not covered by ABS, an no benefit-sharing would be required. This view would thus create a loophole, enabling any user to easily avoid the entire ABS issue, without any sharing of benefits or results, or indeed any notice regarding the use of genetic resources.[29]

To close that loophole, it would be necessary to develop a consistent and legally functional rule regarding the ownership of genetic resources, and to apply it to all utilization of genetic resources from a foreign country, no matter how those resources were obtained.[30] It would be nearly impossible to implement this type of a rule, however, because current science does not have a means of tracking genetic resources which would enable a scientist to identify the country providing the genetic resource from a DNA analysis of the genetic material in a particular product. Moreover, many kinds of use of genetic resources are not direct use of biological or genetic material from the species. Instead, they are undertaken through *synthesis* of the genetic or biochemical components. Most important, the use of genetic resources usually occurs in private laboratories and other places beyond normal oversight.[31]

When does ABS end? Transfers, derivatives and Contract Completion

One area that is currently a topic of very hot discussion is the question of "derivatives." Within the regime negotiation this issue must link to a larger issue – how and when ABS rights and duties finally come to an end.

In commercial situations, legal certainty depends partly on knowing exactly what rights or duties one has under any law or contract, but it is equally important for all parties to know how and when those rights and duties end. For most parties to a contract, the value of the contract depends on the value (to them) of what they are giving, as compared with the value (to them) of what they are receiving. Normally, when a contract requires a continuing regular payment with no clear end-point, this greatly decreases the value of the contract to the person who must pay. Moreover, most countries have national laws which state that no contract obligation may continue eternally.[32] There are three key concepts which must be addressed in order to determine what the "end point" of the ABS relationship should be:

- derivatives (*when does change in the resource mean that the ABS relationship is finished?*),
- transfer (*how does the transfer of genetic material, ABS rights and/or research results affect the responsibilities of the provider, original user and transferee?*) and
- completion (*at what point is the ABS contract "satisfied?*).

None of these has been fully decided, however, the "derivatives question" has been subject of the largest amount of discussion up to now. This issue is complicated by the fact that the term "derivative" has many different meanings in law and many other meanings in non-legal situations.[33] Discussions within the ABS-regime negotiations appear to use many of these definitions, without distinction, so that one position is apparently based on one definition without specifying which, and is challenging another argument that is based on a very different definition.

Framework Questions: ABS as Property or Other Right

Even after clarifying the ambiguous concepts above, there is another primary layer of basic issues that must be addressed in the international regime. This layer focuses on the nature of the legal rights and relationship created by every ABS law and/or contract. There are four integrated components of this issue, which are very briefly summarized here: (i) the nature of genetic resources, (ii) the ownership of genetic resources, (iii) the control of genetic resources; and (iv) inconsistencies in the legal approach to genetic resources over the course of ABS.

— Nature of Genetic Resources

After defining genetic resources, it will be essential to determine their "legal status" – that is, to know "what kind of property?" or "what type of right?" genetic resources are. To date, the legal status/nature of genetic resources has not been completely or carefully studied.[34]

As noted above, the term "genetic resources" may mean the genes themselves (*i.e.*, the physical genetic material taken from a particular specimen), or it may mean the genetic information contained in the genetic structure of the species. In some countries, it also means the "biochemical formulas" of the various fluids and solids within the species. Ultimately, the agreed meaning will probably be some merger of these. Contrary to some simplistic solutions, there is no legal system or concept currently in use that deals with a property type or right that is sufficiently similar to genetic resources that we can use that system as a model for regulating the ownership or transfer of genetic resources.[35] Although many commentators assume that genetic resources are a type of property, it is equally possible to view "genetic resources" as a different kind of intangible property — a "legal right to use" genetic information.

— *Ownership of Genetic Resources*

After one determines what kind of property or right is involved, there is another essential question: *Who owns that property (the genetic resource) or who is legally authorized to grant rights in it?*[36] This question affect the user's "legal certainty" – he will only have a legally valid ABS contract if it is signed by the rightful owner or other authorized person.. Normally, most countries and indigenous peoples have very well developed legal systems (traditional or codified) regarding property ownership, however, they normally have many different sets of rules depending on what kind of property is involved. At present, no country has specifically stated from a legal perspective, which national "property" regime governs genetic resources.

Virtually all countries have separate functional rules governing ownership of

- rights in land and permanently constructed improvements,[37]
- movable property,[38]
- common property,[39]
- sovereign property,[40]
- patrimony,[41]
- "intellectual property"[42] and
- other kinds of "intangible property."[43].

Within these categories of property there may be dozens of specialized sub-categories, subject to separate, unique rules, including rules determining who may own (or control) them, how ownership is obtained and what limits or duties apply to owners. There is no "standard" for national laws on property rights.[44] Each country divides resources among these categories differently, and allocates rights and duties of ownership differently. Countries that have formally adopted ABS laws, must still clarify which property classification will govern "genetic resources," in general.

At present, there is still a need for significant research into this legal question. Only one preliminary study has been undertaken, but its examination assumed that "property rights" refers only to land law.[45] A more rigorous legally oriented analysis will be necessary, to enable the regime to address this issue.

— *Can one Realistically Expect to "Control" Access to or Use of Genetic Resources?*

Many of the most vocal advocates addressing ABS (especially those addressing traditional communities and knowledge) appear to assume that, a country or community can and should *control* physical access to its genetic resources and/or traditional knowledge. In fact, however, like any other secret, if even one person obtains traditional knowledge (whether by communication or by testing) or genetic information (from a sample, from test results or in other ways), then it is no longer a secret. If the system is based on "control" of the resource, then it is breaks down as soon as any user obtains genetic *material* or *traditional knowledge* without ABS compliance. The source country or community cannot physically prevent him from conducting tests and research on it nor from using what he knows.

Long before the CBD negotiations, most species, and indeed most kinds of traditional knowledge have been dispersed to a large number of people, agencies and institutions both inside and outside of the source country. To be meaningful, the ABS concept must address these holders, and clarify whether and how they are included within ABS. Administratively, the simplest way would be to consider ABS as a new obligation imposed on *users* who obtain benefits by using the genetic resources, no matter where those resources were acquired (even if indirectly acquired from an *ex-situ* collection or from a researcher who has previously removed the resources from the source country.)[46] This approach would require some kind of mechanism for accounting for foreign collections and collectors, within the system without placing undue burdens on them.

— *Inconsistencies in Legal Treatment of Genetic Resources*

Finally, there are some basic inconsistencies in the "legal life-cycle" of genetic resource ownership, which form serious obstacles to consistent ABS legislation and implementation at the national level. These inconsistencies are the largest, most insurmountable obstacle to ABS implementation at present: The easiest way to describe this inconsistency is in "the four-step paradox of ABS":[47]

- Step 1: There are many potential sources for most genetic resources:
    - *the gene sequences and biochemical formulas of an entire species (subspecies or variety) are duplicated in all of its members;*
    - *there is no way to maintain complete physical control all specimens of any natural species, and their use as samples for research, genetic analysis or biochemical analysis, even if the species is a narrow-range endemic.*
- Step 2: "Ownership" and/or the right to control or dispose of genetic resources, is disseminated among many separate, unrelated holders:
    - *For nearly every species, natural distribution extends to more than one country;*
    - *Under Article 15, every country in which a species is found* in situ *has sovereign rights in the genetic resources of that species;*
    - *Some countries have laws which disseminate the ownership of, genetic resource widely, giving separate ownership of a species' genetic resources to every individual who owns any specimen of that species;*
    - *Despite this diffusion of ownership, a country (community, person) that owns even a single specimen of a species may grant access to its genetic resources without consulting any other country or person who has a parallel ownership of the genetic resources of that same species.*
- Step 3: The user of genetic resources may need only a relatively small sample, obtained from one provider, in order to be able to utilize its genetic resources.
    - *modern industrial and commercial development processes can often find ways to duplicate or synthesize a species' genetic and biochemical elements based upon only a few samples or in some cases, no samples at all (if they receive detailed research data[48]);*
    - *once the initial research and development is complete, the user will often need no further physical specimens from any source.*
    - *This will be true regardless of whether the user first obtained an ABS contract or permission or not.*
- Step 4: Following access, some users try to convert the non-exclusive genetic resource (legally held and potentially usable by a great many providers) into an exclusive resource, by patenting the naturally occurring gene, rather than only patenting their innovation or invention. [49]

- *If they receive the gene patent, the users could prevent (or require a royalty on) every other person, country or entity from any further commercial or pre-commercial use of the gene. This would theoretically prevent use or other transactions by (i) the country of origin, (ii) other countries-of-origin of the same genetic resource, (iii) other holders in those countries, or (iv) other users who may seek access to that genetic resource in the future*
- *Arguably, this kind of IPR defeats the purpose of ABS (which was intended to provide an incentive for conservation and sustainability), since the financial or potential value of species will be devalued following the issuance of the patent, thereby diminishing the conservation incentive.*[50]
- *This type of IPR would also defeat the purpose of patents which has been described as encouraging and protecting innovation. By contrast, an IPR which restricts the ability of other innovators to use the species' naturally occurring building blocks in other new products would appear to be an impediment to innovation.*[51]

This paradox boils down to a simple question: *If the user obtain his right to genetic resources from one of a large group of holders, how can he rationally convert it into an exclusive right (patent of the natural gene or traditional variety) without permission from all other holders?* Or stated another way, *Why should the right of one person or community or country "win" over the identical right of others?*

A "Binding Regime"—the Enforcement Problem

Another major framework concept that must be formally addressed is "enforceability." This issue has often been spoken of as "the creation of a *binding regime*" (which leads to fruitless arguments and discussions over the meaning of "binding" and the fact that any commercial legal regime will have both binding and non-binding elements.)

Enforceability questions and "binding regime" arguments sometimes distract the negotiators from a much more important question – whether it is possible for any part of the ABS regime to be enforceable *as a practical matter*. Many (perhaps most) of the problems discussed above cannot be enforced in courts. Consequently, most ABS claims are tried only in "the court of public opinion" (the press, the internet and other forums) resulting in negative publicity and other harms to users, without ultimately providing any remedy to providers and source countries. This creates a spiral of increasing distrust, more administrative requirements (in an attempt to make the ABS responsibilities stronger and more binding) and, often, increased costs and longer processing time in obtaining the rights to use genetic resources.

All of this leads to a basic truth known to all lawyers, government administrators and commercial entities: *If a system is non-functional or imposes insurmountable obstacles to the parties, it does not matter what the system says – whether it is "binding" or "enforceable" or not – nobody will use it.* No sector's interests will be served if the ABS system becomes unusable or so unwieldy that is discourages or prevents users from seeking ABS contracts.

In fact, of course, a regime may not be "enforceable" or "binding," unless it can be clearly overseen, externally validated, and legally understood and applied. It will not matter whether a law states that it is "legally binding" or that it must be legally "enforced," if it is not practically possible for courts, agencies, the parties to a contract, NGOs or other beneficiaries to take legal action to enforce it. At present, most proposals for an ABS mechanism would not be "practically enforceable,"[52] because there is no way to know whether the user is complying, and no practical way to obtain evidence of this.

For example, if a law or contract states that the user will contribute 0.1% from every sale of a product that uses a genetic resource, how will that provision be formally implemented and enforced? In order to implement and/or enforce such a law, one of two things must happen. Either –

- the user will pay voluntarily, without oversight or enforceability; or
- if the user does not pay as required, someone (user government, provider government, provider, NGO or other party) must bring some type of legal action – seek agency enforcement, go to court, go to an arbitration or mediation board, or some other nationally recognized mechanism. No matter which mechanism he chooses, in order for the deciding body to force compliance, the complaining person must, at minimum –
    - know that a user has used certain genetic resources without obtaining or complying with relevant permission and benefit-sharing;[53]
    - undertake measures (gain access to the user's facilities or obtain definitive scientific tests) to obtain and document legally valid proof that such utilization has occurred;

- know and document proof that "benefits have arisen" and what those benefits are;
- bring an action against the user under law of a country with jurisdiction over the user, which law must specifically clarify what "genetic resources" are and that use of foreign-origin genetic resources is not permitted without benefit sharing; and
- clearly identify which country is the source country of the genetic resource, in a manner that satisfies the legal requirements under that law.

These requirements may be different in different countries. The complaining party must meet the standards of the country of jurisdiction, which usually means that he will need to obtain the assistance of lawyers in that country or other persons who know its requirements.

This can be very expensive, but is only one of the ways that legal enforcement can be costly. Unfortunately, as a legal matter, the current view of the ABS regime places the burden of bringing action on the "country providing resources." This effectively prevents legal enforcement in most cases. The regime cannot provide much benefit to developing or least developed countries, if it forces them to protect their rights, without alleviating the cost and technical limitations on their ability to do so.

For many reasons, however, it is not possible to shift this burden directly to the user country. ABS cannot be executed by a "command and control" system, because most utilization of genetic resources happens in private laboratories and other areas. Even the richest developed country will not have sufficient manpower to inspect all facilities, and to undertake the relevant scientific analysis to determine if they are using genetic resources. Even if they could, they would not be able to know which country the resources came from without compliance from the user. Thus, it is almost impossible to document violations by evidence that would be acceptable in courts in most OECD countries.[54]

To the author, it appears that the only way to create an effective and functional benefit-sharing system will be to adopt strictly overseeable "incentive" and motivation measures, which encourage users to comply with benefit-sharing requirements.[55] In essence, the user must obtain something of value to himself, which will make it worthwhile for him to comply, and to demonstrate his compliance with appropriate evidence.[56]

Conclusion: Subsequent Steps

The foregoing is not a roadmap to the completion of the international regime, but only a list of the next layer of activity. Once the negotiations have gotten past the initial concerns set forth above, they will have agreed on the basis for the broad framework *on which to build the regime* – they will know, for example: (i) what kinds of specific measures must be adopted by all countries, and which must be addressed by the international instrument, (ii) what resources, activities and benefits will trigger the regime, (iii) who owns the resources and/or has the right to grant "access" to them or permit their utilization; and (iv) how the user's rights under an agreement with one provider country, community or individual affects the interests of other providers/holders of the same genetic resource.

At that point, however, the result will not be a regime, but a framework for creation of a regime. The next layer of issues to be examined would include critical questions such as the following:

- How will the ABS regime effectively integrate with the wider objectives set out in Article 8j of the Convention?
- How will the international regime address "research users", in a way that
  - will not create undue obstacles or inordinate costs for academic, conservation and other non-commercial researchers, AND
  - will not create a loophole that would allow commercial users to acquire and utilize genetic resources without ABS compliance?
- How can the international regime serve as a "pillar" of the CBD, helping to uphold the other two CBD objectives – conservation and sustainable use of biodiversity?[57]
- How can the ABS regime can operate in harmony with the ITPGRFA,[58] and potentially develop a means of integrating with other international regimes of relevance?[59]

Thereafter, there will still be another layer of negotiations will be required to create and fine tune the specific legislative requirements that will be imposed on countries, and the specific international requirements, systems and institutions that the Parties decide to adopt.

At that point, one key necessity at that point will be definition of the relationships of the various parties within ABS transactions. For example, the ABS regime will need to

- clarify the concepts of
- "country providing genetic resources" (variously shortened to "source country" or in some cases "provider country"),
- "country of origin" (which is quite different in meaning from "country providing genetic resources") and
- specifically determine when and how genetic resources could have been "acquired in accordance with this Convention (Art 15.3) particularly when they were collected prior to the convention or for non-ABS purposes (taxonomy, botanical gardens, etc.)

Currently, these issues appear to be interpreted in very different ways by various countries, communities, observers and others.[60] Development of an agreed or consensus view of these matters will be essential, before the regime can be completed.

Endnotes

[1] Johannesburg Plan of Implementation Article 42 o calling on countries to:

> (o) *Negotiate, within the framework of the Convention on Biological Diversity, bearing in mind the Bonn Guidelines, an international regime to promote and safeguard the fair and equitable sharing of benefits arising out of the utilization of genetic resources.*

[2] Decision by the COP-7, UNEP/CBD/COP/7/21, VII/19 D p. 299.

[3] The extreme complexity of the ABS problem has led to a situation in which the negotiations are becoming more specialized and smaller with each meeting., to the point that it begins to resemble a cabal. One person who has participated in ABS discussions from their inception has sometimes referred to the group of negotiators, experts and observers involved in this issue as the "ABS Mafia."

[4] Article 1 states the Convention's objectives as follows:

> *The objectives of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.*

[5] CBD, Art. 15.2, 15.6, and 15.7. The other provisions of article 15 state that Parties have sovereign rights over their genetic resources; that the system applies to genetic resources from a "country of origin" or from a country that has obtained a legal right to the genetic resource from the country of origin, and imposes contract-like requirements of "prior informed consent" and mutually agreed terms both on access and on benefit-sharing.

[6] Article 15 contains the entire regime-creating language of ABS, and is only 7 clauses, embodying a total of 275 words. In normal legislative practice, this would be approximately enough language to define one major term or specify the scope of the instrument (neither of which is done in Article 15. By comparison, CITES, whose four legislative requirements are relatively simple in concept and were not

generally ambiguous or controversial at the time of adoption, expends over 5000 words on the legislative/permit regime alone.

[7] This simple view prevailed for years. Only within the last three years have the inconsistencies described in this paper begun to be seriously discussed in international forums.

[8] Articles 16 and 18, 19, 15.6, and 17, respectively.

[9] The ABS concept is also tied to five key definitions contained in the Convention, ("biological resources," "biological material," "country of origin," "country providing resources" and "genetic resources") found in Article 2, as well as five other ABS-related phrases found in small clauses within Articles 16-21 (some would add Article 8).

[10] The CBD Secretariat maintains a database of national ABS legislation maintained online at http://www.biodiv.org/doc/lists/nfp-abs.pdf. National laws therein include a variety of different levels of regulation, leading to varying counts of how many are "regulatory systems" and how many are "mentions."

[11] The Bonn Guidelines were developed through a series of meetings – the Second Expert Panel on ABS, the first meeting of the Ad-hoc Open-ended Working Group on ABS and COP VI, the Bonn Guidelines were, originally adopted as an addendum to CBD Decisions 6-24 (UNEP/CBD/COP/6/24), and in 2002 were reproduced in a booklet published by the CBD Secretariat.

[12] Although it is the first to be finalized and adopted, the ITPGRFA is not the only process ongoing in other forums relevant to ABS. See, e.g., the discussions in the WIPO Standing Committee on Law of the Patents (SCP), and in the TRIPS Council of the WTO, and the work of the various international bodies focusing on traditional and indigenous knowledge, including the CBD's Article 8j Working Group. These processes have generally attempted to utilize (i.e., to wait for clarification of) the CBD definitions and concepts. Another international process, focused on marine genetic resources, is the deliberations of the UN Intergovernmental Consultative Process on Oceans and the Law of the Sea (UNICPOLOS). In this process, however, the meaning and application of CBD terminology has not been used, so that much of the "marine genetic resources" discussion has focused on applying limits on the taking of samples – a "sustainable use" matter – rather than on ABS and the CBD's third objective. See report of the 8th Meeting, at http://www.iisd.ca/vol25/enb2543e.html. Consequently, this process has not made any progress that could be used to identify special ABS coverage for marine genetic resources. See also CBD, Art. 3.

[13] See, e.g., Burhenne et al. 1994. Some commenters, although recognizing these problems, assumed that they would not prevent implementation. This assumption was not unreasonable. See Glowka, 1998. It is common for national lawmakers to find and adopt specific legal solutions to international implementation problems and for those initial solutions to be later adopted by other countries so that they become eventually the international solution. Unfortunately, in the case of ABS, no country has yet addressed the legal problems described in this section. Thus, there is no national legislation that could be generalized to become a general approach to ABS implementation. Instead of addressing these problems, however, many commentators simply felt that they could be ignored, suggesting that by using the private contract mechanism for granting access to genetic resources the Parties could avoid the need to clarify the various imprecise and ambiguous elements that are essential to ABS functionality.

[14] The following sections of this paper will look at some of the underlying causes – the reasons that countries have not been able to adopt legislation.

[15] A few developed countries have begun processes to develop such systems, but so far, Australia is the only developed country to have formally adopted provider-side ABS legislation.

[16] Most countries that have adopted ABS laws have noted that these systems are not functional or are, at least, seriously flawed in terms of their implementation.

[17] "User measures" is the common way to refer to the obligations under CBD Art. 15.7, quoted in full above. Moat relevantly, it requires that "each Contracting Party shall take legislative, administrative or policy measures, ...with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilization of genetic resources ...." A few countries have adopted laws calling for patent-related disclosure of the origin of genetic resources used in the patented innovation. However, most of these are voluntary measures whose primary result is to give the user country some information which it will keep in a public database that might be accessed by the provider country. Even where such provisions are mandatory, the user's failure to comply will not affect the validity of the patent or create any obligation (or incentive) to share benefits.

[18] There are many possible reasons for Parties' poor Article 15 performance to date. National legislative draftsmen generally find it impossible to create legislation that implements ABS due to the ambiguities and uncertainties regarding the practical meaning of Article 15. These points, and the factors that have formerly (apparently mistakenly) been claimed as the reason for inaction, are considered in more detail in Cabrera and Lopez, 2007 at 1.2 and 2.1.3, and Tvedt and Young, 2007 at Chapter 2.

[19] This issue is discussed in more detain in Tvedt and Young 2007.

[20] See note 27.

[21] One approach to creating internally consistent definitions of these three concepts and the relationship between them is found in Tvedt and Young, 2007, at chapter 4. It should be noted, however, that many other options are possible. The parties need to simply choose one option and use it as a basis for creating the rest of the regime system.

[22] There have been so many inquiries into this question that a full list would be extremely long. Two recent discussion which are easy for the author to cite are Cabrera and Lopez 2007 at 1.2, and Tvedt and Young, 2007, at 2.7.

[23] One example of this approach is found in the African Union Model Legislation for the Protection of the Right of Local Communities, Farmers and Breeders, and for the Regulation of Access to Biological Resources (formally endorsed by all African Union States, but at this writing, not adopted in whole or in part by any) which applies its benefit-sharing provisions to all "biological resources."

[24] It is possible to design an ABS regime using this approach. In fact, this is generally the orientation assumed by the ITPGRFA. Within the CBD negotiations however, it is not a universally recognized view.

[25] Most analyses of the implementation of globally recognized legal concepts focus on the number of different legal systems (comparing systems based on whether they are structured under principles of "common law," "civil law," "planned economies" and/or "religious law" and noting that (although categorized under one of these classifications) each country appears to provide a different mix of these principles. In fact, however, for purposes of determining whether a particular "international regime" can be legally effective, or provide legal certainty (the primary question relevant to the ABS regime) the more important question about each country is whether it is a "strict rule-of-law" system or a "flexible legal implementation" system. The concepts of international commerce tend to expect that all countries will function under the strict rule of law (that is, applying laws and legal principles in a rigorous way, based on precedent or other specific rules which assume that each court's decisions (and thus the actions of any person whose transaction or activity might end in a court) are basically "replicable." In fact, however, nearly all developing countries apply the law in a more flexible

way, based on the wisdom and understanding of the particular official (agency, court or appeal to superior officials) to read and understand the policies and laws and use them to come to a decision which that official believes is just and fair. For officials applying law in this way, the fact that a strict interpretation of two policy statements results in conflict and inconsistency would not present any serious obstacle to coming to a legally accepted decision. In countries that operate using a a stricter (replicability-based approach to the rule of law, however, such inconsistency could make the entire system un-implementable ("void for vagueness.") Consequently, they could not adopt a law or series of laws under which genetic resources have many different interpretations. For ABS, this poses a serious problem, since the primary use countries in North America and western Europe, as well as most "common law" countries and some other OECD-participating non-member countries (such as Brazil) operate under strict "rule of law" legal systems, and are thus currently unable to adopt ABS legislation.

[26] Discussed in more detail in Tvedt and Young, 2007, at 4.1 et passim.

[27] Specifically, given that factual data cannot be protected by patent and may be a trade secret, how can it be shared with the source country while still protecting it as a trade secret? Obviously, if one waits until patenting or publication by the user, then the user will no longer need to be concerned about maintaining secrecy; however, at this point, the source country's "share" is meaningless, since the information is essentially public and available to all.

[28] See Holm-Müller et al., 2005; Latorre, 2005; Frison and Dedeurwaerdare, 2006. At minimum, results of recent "user surveys" indicate that most users do not know or particularly care what the ABS provisions require, assuming that they are exempt, so long as they acquire GR through secondary sources (collections, collectors and middlemen) outside the source country.

[29] A representative of the pharmaceutical industry specifically stated that in future, to avoid ABS complications he would always acquire his genetic material from other collectors, both those who have recently collected the materials and botanic gardens whose collections include foreign-collected materials and their progeny. Presentation of T. Henkel, "A Perspective from Pharmaceutical Industry," Presentation to High-level Experts Meeting - Addressing the Access and Benefit-Sharing (ABS) Challenges in the Context of the Convention on Biological Diversity (Tokyo, 8-9 February 2007) and other remarks in that meeting

[30] At that point, since no country has adopted user measures, the user's use of the resources will be legal under the user-country law . It is normally not possible to control or track the physical ability to obtain samples, unless either (i) the users voluntarily provide the relevant information and agree to these controls, or (ii) both source and user countries (and other countries in which the biological material has been taken) are willing and able to oversee all potential utilization activities involving genetic resources derived from any biological material. It is still unclear whether either of these actions is required under the CBD.

[31] Normally, to gain access to private property, one needs legal authorization – approval from a judge or agency, subject to a law which governs reasons for entry and limits the action that may be taken.

[32] For lawyers, this concept is sometimes called the "Rule Against Perpetuities." No matter what it is called, it is normally a very complex concept, and differs from country to country.

[33] In the discussions, it appears that some negotiators equate "derivative" with "extract." Others assume that, including "derivative" would make the obligation of the user permanent. The strictest version, would be as follows: a "secondary user" buys a commercial product which was developed by a "GR-user" under an ABS contract. In that transaction, the GR-user would pay a share of the purchase price to the original provider. However, if the commercial product is a "derivative",

the secondary user would have to pay benefit-sharing on his new product, essentially creating a double payment.

[34] As noted in footnote 45 and accompanying text, the most recent study has assumed, that genetic resources will be governed by national law governing land. This assumption is probably incorrect.

[35] There is no example in property law, including intellectual property law, in which an identical intangible resource can be owned by many countries or persons, each of whom has an unfettered right to sell or transfer it. This issue is discussed in a forthcoming book: Bhatti, S., S.Carrizosa, P.McGuire, T.Young. 2007. Contracting for ABS: The Legal and Scientific Implications of Bioprospecting Contracts.

[36] At least one country, Australia, has legislated in a way that indicates that any person that owns or possesses as specimen of biological origin also owns the rights to genetic resources it contains. See AUSTRALIA, Environment Protection and Conservation Regulations, 2000, Statutory Rules 2000 Nº 181, as amended (taking into account amendments up to SLI 2006 Nº 131, Parts 8A, 9, 10, and 17). And see, Queensland Biodiscovery Act, Act Nº 19, 24 Aug 2004; and other documents available on the CBD's ABS Measures database. http://www.cbd.int/abs/measures.shtml This provision, however, appears to be inconsistent with the Australian law on patents, which apparently recognizes the right to patent naturally occurring genes, without getting permission from the owners of rights in that material. Consequently, although having espoused an approach, it cannot be said that Australia has, as yet, integrated that approach into its property law.

[37] This category normally includes land and permanently constructed improvements (buildings, roads, fences, weirs, bridges, etc.)

[38] Often including special ownership rules for some types of property (motor vehicles) which are different from other personalty and movable items.

[39] In many countries, for example, water is part of a complex "common property" regime, under which water rights may or may not be linked to rights in land.

[40] This term is generally used to describe government-owned property held by virtue of its sovereign duties to its people, as distinct from other kinds of property which the government controls under other theories.

[41] Patrimonial concepts vary greatly, but generally focus on establishing a single governmental ownership concept for dealing with the property which is held on behalf of the entire citizenry. It is similar to the concept of "public trust."

[42] Intellectual property is a 'legislatively created" concept, under which one who creates or invents something is given special rights to control its use or commercialization.

[43] There are many other kinds of intangible properties including shares in a company, intangible rights in land (easements, profits, appurtenances, etc.), trade secretes and other properties which are not tied to a particular tangible item but are clearly and specifically held by a definite person or entity.

[44] The sovereign right of countries over their natural resources has been generally recognized for many decades. Mgbeoji, 2001. Prior to 1992, however, no legal instrument suggested that there was any kind of commercial right of any person or country to exert dominion, ownership or other legal rights in the genetic information or other characteristics of any naturally occurring species or variety of plant, animal or other biota..

[45] 2007. "Report on the Legal Status of Genetic Resources in National Law, including Property Law where Applicable, in a Selection of Countries." UNEP/CBD/WG-ABS/5/5.

[46] As noted above, in order to effectively impose such a new obligation, it would seem necessary for the system to provide some sort of quid pro quo and/or create incentives or other motivations for users and countries with significant numbers of users under their jurisdiction.

[47] The following description is taken from an interin draft of a future book: Bhatti, S., S.Carrizosa, P.McGuire, T.Young. 2007. Contracting for ABS: The Legal and Scientific Implications of Bioprospecting Contracts. None of the other authors bears any responsibility for this description, which may or may not appear in that book.

[48] See Mgbeoji, I., 2006.

[49] Although the technology needed to isolate natural genes is generally available (i.e., there was no innovation in the isolation process), and no other "inventive step" is involved, these patents have been upheld in at least two countries (Australia and the US).

[50] In theory, it also defeats the purpose of IPR protections, which are intended to enable innovation, rather than to prevent access to raw materials and natural examples.

[51] Consider the possibility that one user could patent coltan, charging a royalty to all industries using it in telephone or developing new uses for it in computer and other technologies. The result would be an impediment to future technological innovation, and would also negatively impact the markets and prices for copper and coltan, affecting the value of those resources.

[52] For a private contract to be fully "binding," it must be "enforceable", in cases of disagreement between its parties. This creates a problem for ABS, where many basic components of the contractual system are un-agreed indistinct or vague, since courts and government agencies normally will not even attempt to enforce contracts that are ambiguous. This is not a choice on their part – it is mandatory. It is impossible to apply the rules of law to achieve reproducible results, when primary facts cannot be pinned down. A more complete discussion of the obstacles to enforcement of ABS is contained in Young, 2007.

[53] Unless the person has practical knowledge that the use is ongoing, he will not know that he should investigate the private actions of the user. It may be (marginally) possible to obtain this knowledge in cases where the user has obtained an ABS permission or contract, but will be virtually impossible as to other users.

[54] See Young, 2005 addressing the problems of "legal certainty" in detail; Tvedt and Young 2007, at Chapter 3, addressing the lack of "user-side measures" and Young, 2007, regarding the problems of enforcement if ABS operates under "command and control" approach.

[55] A discussion of the manner in which incentive and motivation can be integrated into the international regime is found in Tvedt and Young, 2007, at 3.5 and 6.2.

[56] Such evidence might be in the form of a "certificate of benefit-sharing" or other certificate. Until the incentive system is created, however, it will be impossible to design a certificate, and the system for obtaining such a certificate, verifying its authenticity (when the certificate is used), and maintaining confidentiality regarding its contents. Hence, recent international discussions of the creation of an "Internationally Agreed Certificate of Source, Origin or Legal Provenance", although of great interest, may not have been timely. It will be useful to revisit this issue when the regime is more nearly completed.

[57] Most contemporaneous accounts stated that the three objectives of the Convention are three inter-dependant "pillars" on which the CBD is founded . Hendrikx, et al., 1993.

[58] Although thought by some to be the only practical instrument on ABS, the ITPGRFA currently appears to utilize an approach which is significantly different in function and framework from Article 15. Among the most obvious inconsistencies between the two is the fact that the ITPGRFA has assumed a definition of genetic resources which presumes that the term means the same as "biological resources" or even "biological diversity. As noted above, this choice has not been adopted by the CBD, suggesting that there may be a significant

difference between the two instruments at the most basic level. The ITPGRFA states that it is "in harmony with the CBD" (ITPGRFA, Art. 1.1), however that statement has not yet been mirrored in any statement adopted by the CBD COP. Possibly this omission is significant, given that the "harmony" between international instruments is normally determined by the manner in which they are implemented. If a country can and does implement both instruments in a harmonious way, then the instruments are "in harmony," at least in that country. If, however, two international instruments are facially inconsistent, but a later instrument states its intention of being "in harmony" with the older instrument, it is usually felt that the newer instrument will have to be interpreted (or rewritten) in a way that causes it to harmonize with the other instrument. Singer/Sutherland, Statutory Interpretation, under "harmony."

[59] See note 13, above.

[60] An introductory discussion of these definitional issues is found in Tvedt and Young at Chapter 2.

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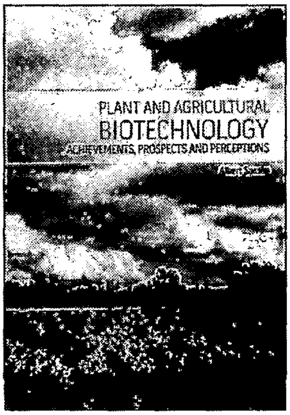
Book Review

Plant and Agricultural Biotechnology: Achievements, Prospects and Perceptions by Albert Sasson

COCyTE, N.L. (Ciencia Y Technología De Nuevo León, México) UNU/Institute of Advanced Studies and BioEuroLatina, Maxico. Pp.444, 2006.



Over the last few decades, there has been significant development of biotechnology through a very wide spectrum of human activities, from medicine and health care to agricultural and food production, and through biofuel production, environment protection, bioremediation and biomining. The present book mainly provides an overview of conventional agricultural biotechnology, genetically engineered crops extension, commercialization, benefits and prospects, innovations in advanced crop biotechnology along with the successful case studies of many developing countries. It also addresses the future of agricultural bio-industry in both technologically advanced and developing countries.

The book broadly consists of thirteen comprehensive sections or (chapters) though without any numbering followed by conclusions and prospects of agricultural biotechnology for the betterment of the human kind. The first chapter highlights the status of conventional agricultural biotechnology as the most widely adopted biotechnology in developing countries, where agriculture plays dominant role. Some of the interesting success stories of plant-tissue culture and clonal multiplication of crops in Malaysia, Cote d'Ivoire, Indonesia, Central Africa and Latin America, Thailand, Colombia and Ecuador have been presented. This technique is very effective even in rudimentary conditions and provides a regular source of income to the marginal framers. In Argentina, an autotrophic and hydroponic system (SAH) has been developed for the *in vitro* production of potato plantlets. However, within a month's time from only 200 plantlets produced *in vitro*, 10,000 potato plantlets could be obtained. Similarly, for rapid expansion of cassava production, a technique was developed at the National Research Council Canada Plant Biotechnology Institute, that enabled the production of mosaic disease-free plants from *in vitro* cultured shoot apical meristems. Later, both these techniques have been successfully replicated to other countries as well for e.g. Bolivia, Chile, Colombia, Ecuador, Peru, Venezuela, Colombia, Africa and India.

For the commercial production of plantations banana was one of the first crops to be multiplied *in vitro*. Further, clonal multiplication of coffee, oil-palm and date-palm are the success story of conventional agricultural biotechnology.

After a brief explanation and definition of genetically engineered plants and crops in the second chapter, the extension of genetically engineered crops have been thoroughly discussed in third chapter of the present book. Around fifty crop species viz. maize, soybean, wheat, potato, tomato, papaya, melon, sugar-cane and cotton have been genetically transformed are insect resistant, disease and virus resistant. These crops are designed to tolerate climatic stresses such as cold, heat and drought. It has been also estimated that the net economic benefits to producers from transgenic crops are enormous. According to the global study by Australian economists on transgenic grains, oilseeds, fruit and vegetables, projected a global potential gain of US$ 210 billion by 2015. Further, it is estimated that application of biotechnology in rice would be more beneficial to many Asian countries to produce around 770 million tons of rice required to feed an additional 650 million rice consumers. Likewise, some commercial crops like maize, wheat, soybeans, banana, sugarcane and coffee are the best examples of the extension of genetically engineered plants.

The fourth chapter entitled *Innovation Prospects for Advanced Crop Biotechnology* discusses its status in developing countries viz. China, India, Brazil, Chile and Argentina as they are in constant pressure to increase their production as well as productivity. The developing countries are continuously facing challenges to protect environmental and biological diversity and subsequently diversify agro-products to meet the requirements of the consumers. It is suggested that, in this scenario, the advanced agricultural biotechnology can contribute to meet these challenges. The chapter also discusses in detail the different initiatives under taken for the development of biotechnology in several developing countries viz. China, India, Brazil, Chile, Costa Rica and Argentina.

The future of agricultural bio-industry in both technologically advanced and developing countries has been analyzed in the next chapter. However, the two most challenging agricultural problems which developing countries face today are to provide sufficient food to billions of human beings, while preserving their biodiversity. The rapid increase in population and their demands for food have not been adequately taken care by the industries and services sector. It is therefore crucial to increase agricultural production through biotechnological research which has the potential to tackle the major problems of the developing world related to poverty, food, hunger, health and environment. The book identifies certain solutions to the challenges for agriculture and emphasized on agricultural R&D innovation to enhance productivity and improve natural resource management, increase household skills and know-how and lower food prices for consumers. The introduction of transgenic cotton and soybeans varieties in Africa and US are the illustrative example of the positive impact on trade of transgenic crops, apart from establishing commercial relationships between the exporting and the importing country. Farmers as well as the companies are benefiting from growing and selling transgenic crops like cotton, soybeans, oilseed rape and maize, primarily from the higher price of seeds. In India, ITC, an Indian conglomerate directing the farmers to use hybrid seeds, fertilizers and maintain wider space between plants to increase the soybean yields.

Overall economic impact and benefits of transgenic crops are analyzed in great detail in the chapter entitled 'Benefits *of Transgenic Crops.'* The chapter documented that in US due to extensive adoption of biotechnology derived varieties there are stances of higher yields, higher farm incomes and reduced pesticide use. For the benefit of the consumers, Japanese researchers have identified the ways to genetically modify the presence of enzyme (lacrymatory factor synthase) in onions that causes irritant effects to eyes. Monsanto and Cargill have formed a joint venture to modify the protein composition of soybeans and maize grown for animal feed. Weed management is an important incentive for farmers which can also contribute to higher yields. In the chapter, author also stressed that improvement in the nutritional quality of food is as important as to increase the higher productivity. Very rich examples of bioengineering crops have been mentioned that are capable tc reduce many micronutrient deficiencies.

The book also presents the potential hazards of genetically modified crops as well as the evaluation and management of risks associated with transgenic crop cultivation. In this chapter, author has beautifully explained in detail the journey of migration of monarch butterfly from US and Canada to Mexico and their exposure to the nature. However, it was stated that the biggest threat to the monarch's survival are man-made deforestation, development of highways and suburbs. The concept of 'bio-invasions' has been also considered as the major threat to biological diversity and the impoverishments of human communities. The incorporation of the precautionary principle in principle 15 of the Rio Declaration and in the preamble to the CBD as a basis for decision making and risk assessment with respect to the transboundary transfer of GMOs or living modified organisms (LMOs) have been analyzed in the next chapter that may have adverse effects on the conservation and sustainable use of biological diversity. The author throws light on the flaws in the precautionary principle as the principle itself provides no guidance on its application in situations where an action could lead to uncertain benefits and harms simultaneously. It has also been suggested in that case, prior to its application, there is need to formulate hierarchical criteria on how to rank various threats based upon their characteristics and the degree of certainty attached to them Human mortality and threats to the environment can be associated with the public health criterion in this context. Apart from this, immediacy, uncertainty, expectation value, adaptation and irreversibility criterion have been put forth for consideration.

The author also cautioned about the risk assessment associated with genetic crop cultivation, as some degree of hazard is always associated with every technology. However, risk also comprises an outrage component which covers everything about risk apart from its possible effect on people. It is therefore important to be aware of the factors associated with the risk which are the contributing factors of an outrage. Findings of quite a few studies on the consumption of genetically modified food and its effects on human health and environment have been presented with a mixed picture. Biosafety regulations to deal with the health and environmental rDNA-derived products and in particular transgenic crops are a significant step in this direction. Though many international agencies like UNEP/GEF, OECD, EC, FAO and ISNAR are actively involved in the harmonization of biosafety regulations in different regions. ICGEB Biosafety Unit was established to provide services relating to GMOs and their release into the environment, apart from information dissemination and the establishment of a biosafety clearing house, scientific training in risk assessment for the release of GMOs in the environment. Various policy measures and initiatives undertaken in both developing and developed countries with regard to the cultivation of transgenic crops and biosafety regulations have been discussed at length to present their holistic approach on the various issues involved in it.

The author raised a very important question in the chapter *'International Regulations and Trade Disputes,'* is the Cartagena protocol on biosafety a hindrance for advanced agricultural biotechnology? The role of Codex Alimentarius Commission (CODEX) has also been discussed which are responsible for adopting international standards for the trade of foodstuffs derived from transgenic organisms. It also adopts standards that may be used by its 162 participating governments to develop national regulations. It was stated that two WTO Agreements are relevant for CODEX standards, viz. the SPS Agreement applies to those national laws designed to protect life and health from risks arising from, among other things, additives, contaminants, toxins, diseases and pests. The other TBT Agreement applies to all national technical regulations and standards governing product characteristics, labeling and packaging. However, the focus on food safety in international trade and in trade agreements has made trade issue alike for many developing as well as developed countries. In addition to risk assessment involved in releasing transgenic crops in the environment, the concept of biovigilance has been put forth to keep a check on their patterns of behavior. Accordingly, all the plots cultivated with transgenic species should be mapped with respect to their characteristics.

The issues of *'Traceability, Labelling and Transparency'* of products derived from GMOs, as well as the coexistence of the latter with conventional and organic agriculture has been thoroughly discussed in the next chapter. It states that traceability implies the monitoring of products through the whole chain of production and distribution and its potential effects on human health and the environment. In this context, labelling is the key factor that indicates the presence of transgenic organisms on the food labels. The French Agricultural Research Institute (INRA) and the University of Grenoble, from the perspective of traceability, labelling and transparency proposed three options on the acceptance of transgenic organisms. Firstly, the complete phase out of production of GMOs, secondly the total submission in the scientific views and recognize these GMOs harmless and safe for human health and environment. And, lastly, they emphasized on the establishment of two separate production chains, one transgenic and the conventional one, for the consumers to decide on their own. The French researchers opted for the third option.

Though the issue of coexistence between the three types of agriculture based on conventional crops and intensive farming, organic farming and transgenic crops has been raised at the Council of European agriculture ministers in 2002. Organic farming which has a strong growth rate across the European Union's member countries might threatened by contamination by genetically engineered crops, when they are gradually adopted and grown. The chapter highlights that, later the European Commission considered that the modalities of coexistence between transgenic crops and conventional ones should be decided upon by the member states. For that, a three year programme called Sustainable Introduction of GMOs into European Agriculture (SIGMEA) was launched to create awareness about the co-existence.

The chapter also reveals the comprehensive measures undertaken by France to ensure crop existence in the case of maize According to a research study, modelling and trials have shown that a minimum distance of hundred metres was necessary between a transgenic and a conventional agricultural plot in order to keep the level of transgenic material under 1 per cent in the conventional crop. Further, in case of two plots adjacent to each other, flowering in the plots should occur at a four-day interval. Though EC has adopted the pro-GMO attitude, whereas it seems that new members of the European Union are not more enthusiastic about GMOs than their predecessors, although countries like Hungary, Poland and Romania are found to be in favor of cultivating transgenic crops. On the other hand, researchers and experts also argue that GM crops can also bring benefits to small farmers and contribute to a more environment-friendly agriculture.

The issue of social acceptance of biotechnology derived products through the debate on patenting genetically engineered organisms has been examined in the chapter entitled *'Intellectual Property Protection: Impact on the Acceptance of Transgenic Crops.'* An overview of *sui generis* legislation in the shape of the Plant Varieties Protection and Farmer's

Right (PVFR) Act, 2001 was enacted by Indian Parliament to provide protection of new crop varieties has been mentioned. It has also been recognized that patenting and intellectual property protection are important ways to ensure a fair return to industry for its investments in R&D of new knowledge and technologies as they are vital ways to foster continued national innovation.

Besides, the issue of patents, it highlights that WIPO also addressed the issue of the growing gap between developing and developed countries with respect to intellectual property laws and its effect on access and rights to genetic resources. Further, it also aims to make an inventory of traditional knowledge in order to prevent its illegitimate appropriation by a third party. The concept of bioprospecting means the exploration of biological diversity for commercially valuable genetic and biochemical resources has been clarified. It also presents the 'access and benefit sharing' system that aims to promote scientific and technological breakthroughs from plant and animal sources while recognizing the contributions and rights of those who cultivate and preserve these resources. Furthermore, it provides a useful source of information regarding an Indian herbal medicine, Jeevani and the traditional knowledge of local Kani tribe. Jeevani is claimed to have anti-fatigue, anti-stress properties and other benefits. This case study shows that fair benefit sharing arrangements can play a key role in the enhancement of social and economic development among local communities.

Controversy related to the agricultural biotechnology from the different groups of stakeholders like consumer associations, organic farmers, environmentalists on the one hand opposed to the alterations of the foodstuffs and environment contamination. On the other hand, researchers, farmers, regulatory agencies and private industries are mainly concerned with the post harvest conditions and increase in yield and productivity and nutritional value. Apart from this, the debate on transgenic crops also deals with justice and democracy. Role of media coverage of biotechnology is a key factor in the social acceptance of these technologies through transparent information. It creates the general awareness about the potential benefits as well as the risks associated with their commercialization in the agricultural and food sectors. It was emphasized that there is a genuine need to bring science and society closer together to build a "knowledge democracy" in which the community is well informed about the technology and its application for the betterment of the humankind.

The final chapter summarizes the conclusions and prospects from the viewpoint of large consensus that research in developing countries should be linked to the problems and requirements of the local communities in their struggle against hunger, food security and undernutrition. The book rightly concluded with L. Fresco's remarks that "clearly the question is not what is technically posible, but where and how life sciences and biotechnology can contribute to meeting the challenges of sustainable agriculture and development in the 21st century."

On the whole the book gives an indepth account of achievements and prospects of agricultural biotechnology, highlighting different aspects of its benefits and risks with many examples from developing countries. The volume is loaded with comprehensive analysis of the wide range of agricultural techniques and its impact on both developed and developing countries. It is a great source of information for the students, scientists and researchers, civil societies and the stakeholders about the implications and prospects of agricultural biotechnology.

— Beena Pandey

Guidelines for Contributors

ould be submitted in duplicate to the Managing Editor, Research and Information r Developing Countries (RIS), India Habitat Centre, Zone IV-B, Lodhi Road, i 110003, India (Tel. 00-91-11-24682177-2180, Fax: 00-91-11-24682173/ ail: sachin@ris.org.in) Manuscripts should be accompanied by a floppy disc mpatible format, preferably in MS Word, identical in every respect to the hard d on A4—paper on one side only, double-spaced throughout and with ample n all four sides.

multi disciplnary journal. Please explain technical details in simple words for of non-technical readers.

'-ize' '-ization' words; e.g., 'civilize', 'organization': Use British spellings American spellings. Thus, 'labour' not 'labor'.

es (rather than world) for quantities and exact measurements including s (2 per cent; 3 km, 36 years old). In general descriptions, numbers below 10 spelt out in words. Use thousands, millions, billions, not lakhs and crores. Use s for numbers and dates— e.g., 1980-88, pp. 200-202 and pp. 178-84.

tes should be cited in the form June 2, 2004. Decades may be referred to as es'. Spell out 'the twentieth century', etc.

list of references cited in the article and prepared as per the style specified e appended at the end of the article. Reference must be typed in double space, rranged in alphabetical order by the surname of the first author. In case more by the same author(s) is cited, then arrange them chronologically by year of

should be embedded in the text in the anthropological style – for example 61)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary d portion is a direct quote)

be first alphabetical and then chronological – for example 'Rao 1999a, 1999b'.

reference of the same date for one author should be cited as 'Shand 1999a,

xample illustrate the detailed style of referencing:

n, A. O. 1961. *Strategy of Economic Development*. New Haven: Yale University

lumes:

c (ed.). 1999. *Economic Liberalization in South Asia.* Delhi: Macmillan.

from edited volumes:

, W. D. 1989. "Lineages of Dependent Development: From State Control to Economy in Sri Lanka," in Ponna Wignaraja and Akmal Hussain (eds): *The e in South Asia: Development, Democracy and Regional Cooperation*. pp. ew Delhi: Sage.

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., K. P. Kalirajan and R. T. Shand. 1999. "Convergence of Income across tes: A Divergent View". *Economic and Political Weekly,* 34(13): 769-78.

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novations in Production". Unpublished Ph.D thesis. Amsterdam: versity.

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